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THE STRUCTURE AND RELATIONSHIPS OF THE AMERICAN PELYCOSAURIA.

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PERHAPS the greatest interest excited in the morphology of the Permian reptiles of the order Pelycosauria centers about the development of the temporal and quadrate regions as they seem at present to afford the most direct phylogenetic evidence of the origin of the mammals. The fragmentary character of the specimens and the character of the matrix in which they are preserved has rendered advance in the knowledge of the group very slow. In previous papers, both alone and in collaboration with the late Dr. Baur, the author has made known some of the structures of the order, has demonstrated its Rhyncocephalian nature and has given a new definition (Baur and Case '97 and '99). These conclusions were based upon new material, but affected seriously the work of Cope; they were accepted by Cope for but one of his forms only (Diopeus leptocephalus) with the proof that he had already recognized the character in that form (Cope '97). The unfortunate death of Prof. Cope rendered the type specimens temporarily unavailable so that continued study was almost impossible, but the collections have since come into the posses-

sion of the American Museum of Natural History in New York, and through the kindness of the Director of the Department of Paleontology the author was permitted to examine the types during the past summer. As the material was made available to me even before cataloging by the Museum, I desire to express my thanks publicly to Dr. H. F. Osborn for his kindness in the matter.

Unfortunately the most of the type specimens have never been freed from the matrix, Prof. Cope contenting himself with the description of new forms and such characters as could be made out from the uncleaned specimens. A reëxamination of the types in the light of better preserved and prepared material has led me to conclusions very different from those of Cope and of far-reaching effect upon the classification of the Pelycosauria and the related Permian reptiles of other countries.

These conclusions may be stated as follows: —

1. All known reptiles from the American Permian, other than the Cotylosauria, possessed two temporal arches; there is no approach to a single zygomatic arch, as described by Cope in some of them.

2. The Pelycosauria followed a line of development that led to extinction while the persistent line of development was followed in other regions, perhaps in Africa. The progress of development, from a stage represented by Diopeus, is expressed in the skull as follows: —

(a) The depression of the posterior angles of the skull (suspensorial region) by the shortening and degeneration of the quadrate; the bones of the temporal arches remaining distinct but becoming very slender. This process leading to extinction by the weakening of the articular region.

(b) The gradual elevation of the facial region of the skull and the lessening of the transverse diameter through the vertical growth of the maxillary and the narrowing of the frontals and nasals.

(c) The increase in size of the maxillary and premaxillary tusks, the deepening of the diastema, the increasing convexity of the alveolar edge and the development of serrations on the edges of the teeth.

(d) The increase in size of the ectopterygoid process of the pterygoid bone.

(e) Correlated with these changes the development of the enormously elevated neural spines.

Following is a short description of the skulls of the types representing the advancing stages of the development. The genera Dimetrodon, Embolophorus, and Naosaurus are not described, as the first two have been very fully described (Baur and Case '99 and Case[1]) and Naosaurus is very similar to them in the regions under discussion.

Theropleura uniformis. — Only the portion of the skull anterior to the posterior edge of the orbits is preserved; but this much is fairly free from the matrix, and the parts are easily made out. A careful examination of the skull compels me to differ from the description by Cope in one or two points. He mentions (Cope '80) the presence of "at least one large incisor tooth," and says the incisor teeth are separated from the maxillary teeth by a diastema. The anterior end of the snout is crushed, but the incisor teeth are seemingly all preserved, and I could not detect any one that was notably larger than the others; they are small and sharply recurved. Neither could I detect the presence of a diastema marked by any concavity of the alveolar edge of the maxillary bone such as is so persistent in the other American Pelycosauria; it is possible that there was a lack of teeth at this point, but as the bone is somewhat crushed at the point it is impossible to say certainly. As mentioned by Cope, there is no distinct maxillary canine, but the teeth increase in size to near the middle of the series and then diminish so that the 19 from the posterior end is the largest; the whole tooth line and the alveolar edge of the maxillary is straight without a trace of the convexity downward that marks the more specialized form. As described by Cope, the skull is low and acuminate; the orbits are large and the nares are near the anterior end of the snout on the sides. The whole skull is strikingly similar in general outline and appearance to the skull of Proterosaurus, and in just the same characters of a low and broad

[1] A description of *Embolophorus dollovianus*, unfortunately delayed will appear in the Journal of Geology for January and February, 1903.

skull it differs from the specialized Pelycosauria. As the posterior portion of the skull is destroyed it is impossible to say with absolute certainty what was the condition of the temporal arches, but from the other relations of the skull there seems no reasonable doubt that they were as in Proterosaurus, *i.e.*, with two distinct arches.

Cope describes the neural spines as elevated in all the species of Theropleura, but this is not to be taken in same sense as the elevation of the spines in the specialized members of the Pelycosauria. The length of the elevated spines does not exceed two or three times the length of the centrum where in Dimetrodon it is as much as 28 times the length of its centrum.

Diopeus leptocephalus. — The skull of this form is represented by disarticulated fragments which are fortunately quite free from crushing, and from the matrix. The fragment showing the temporal region is made up of the quadrate and quadrato-jugal, the united squamosal and prosquamosal; cemented to these are the pterygoid and the epipterygoid almost in the natural position. These fragments show that the temporal region, as figured by Cope (Cope' 92), was very similar to the same region in Sphenodon which it especially resembles in the united squamosal and prosquamosal. The anterior end of the prosquamosal is missing, but the squamosal is complete and shows the articular surface for the parietal. The posterior edges of the temporal vacuities are preserved and show that they were wide open and somewhat oval as represented in figure 1.

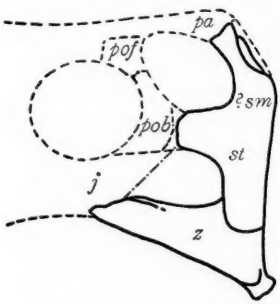

FIG. 1. Temporal region of Diopeus leptocephalus. *pa*, parietal; *pof*, postfrontal; *pob*, postorbital; *?sm* (squamosal) supramastoid; *st*, (prosquamosal) supratemporal; *j*, jugal; *z*, (quadrato-jugal) zygoma. After Cope.

The resemblance to the quadrate region of Sphenodon is somewhat superficial as the quadrate does not appear on the lateral surface but is covered by the vertical extension of the quadrato-jugal. The quadrato-jugal is much stronger than in Sphenodon and has the form of a right angle with one arm vertical and the other

extending horizontally forward. The vertical arm overlaps the outer surface of the quadrate as described and meets the squamosal, the horizontal arm joins the jugal and forms with it a strong inferior bar. Seen from the rear it is evident that the squamosal comes down as far as the lower limit of the quadrate and appears on the outer surface of that bone. The pterygoid comes well up on the inner surface so that the quadrate is practically surrounded by bones and has relatively small vertical extent. Figure 2.

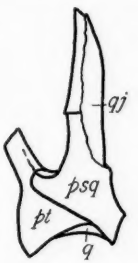

FIG. 2. Posterior view of temporal region of Diopeus leptocephalus. *qj*, quadrato-jugal; *psq*, prosquamosal; *pt*, pterygoid; *q*, quadrate.

The facial portion of the skull is formed almost entirely by the maxillary which presents some peculiarities. It is relatively long and the alveolar edge is almost straight with hardly a trace of the sharp downward convexity of the specialized Pelycosauria. On the inner side of the maxillary the lower edge is locally thickened by the development of a sharp buttress which accommodates the roots of the teeth; near the anterior end of the maxillary there is a single greatly enlarged canine and the buttress is correspondingly enlarged but no where near so much as in the most specialized forms of Dimetrodon, instead there is a strong rib developed on the lower side of the maxillary from the base of the root of the tooth to the top of the maxillary bone. The root does not extend into the bone as far as in Dimetrodon. This maxillary canine is rather more posterior in position than in Dimetrodon, posterior to it are 19 counted teeth and alveoli, but a portion of the bone is covered by a fragment of the lower jaw so that there were probably from 23 to 25 teeth; anterior to the canine are four teeth and alveoli in the maxillary. Where the maxillary meets the premaxillary there is a shallow depression of considerable antero-posterior extent, but it is lined with teeth throughout so that it is but the beginning of a diastema.

The form of the premaxillary is quite similar to that of Dimetrodon, there is a vertical anterior process which forms the anterior edge of the nares. There is but a single large incisor which is the first or inner one and posterior to it there are four much smaller.

Another fragment shows the upper portion of the maxillary and the frontal united by their inner surfaces. The two portions of the maxillary show that it was a thin, elevated plate, but relatively not nearly so high as in Dimetrodon. The frontal differs markedly from the frontal of Dimetrodon and all the specialized Pelycosauria, it is nearly as broad as long, showing that the top of the head was flat and broad. The orbital region is not preserved, but the anterior portion of the preorbital is, and this with the posterior end of the maxillary serves to locate its position with fair accuracy. The front edge of the preorbital is marked by the edge of a pit or foramen which is similar to the pits described by Seeley in Cynognathus and regarded by him as harboring a gland. In figure 3 is shown a partial restoration of the skull of Diopeus illustrating the beginnings of the features found in the more specialized Pelycosauria.

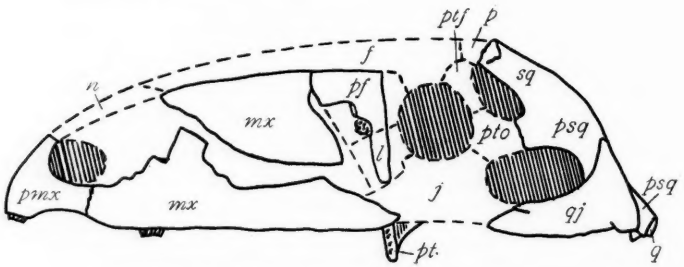

FIG. 3. Restoration of skull of Diopeus leptocephalus. *n*, nasal; *pmx*, premaxillary; *mx*, maxillary; *f*, frontal; *pf*, prefrontal; *l*, lachrymal; *j*, jugal; *pt*, pterygoid; *ptf*, postfrontal; *pto*, postorbital; *p*, parietal; *sq*, squamosal; *psq*, prosquamosal; *qj*, quadrato-jugal; *q*, quadrate.

The pterygoid bone is also interesting as showing the simple beginnings of the peculiar pterygoid characteristic of the Pelycosauria. There is the same tripartite division of the bone, but in the Dimetrodonts the posterior limb extends only as far back as the quadrate and is united with it by cartilage while in Diopeus it articulates strongly with the quadrate. The middle line is destroyed but the external or ectopterygoid process is much more slender and thin than the same process in the Dimetrodonts. The outer surface which abuts against the lower jaw is slightly rugose and the lower edge carries 15 teeth and alveoli.

In Sphenodon there is the same ectopterygoid process but is smaller and perhaps does not touch the lower jaw; it is made up of the pterygoid and ectopterygoid but in the Pelycosauria there is no distinct ectopterygoid that I have ever seen, it is either closely co-ossified with the pterygoid or is between the anterior plate of the pterygoid and the maxillary, a region not preserved in any known specimen. Seeley describes a similar process in the African Theriodonts but says it is made up of the ectopterygoid and palatine.

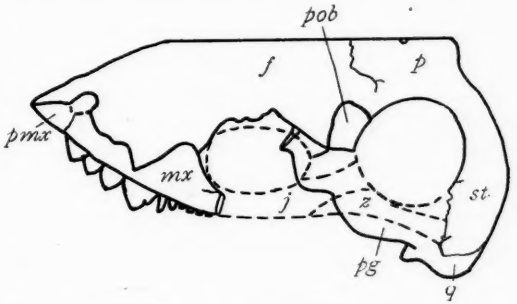

FIG. 4. Edaphosaurus pogonias. Side and top view of crushed skull. *pm.x*, premaxillary; *m.x*, maxillary; *f*, frontal; *j*, jugal; *pob*, postorbital; *p*, parietal; *z*, (quadrato-jugal) zygoma; *pg*, pterygoid; *st*, (squamosal) supratemporal; *q*, quadrate. After Cope.

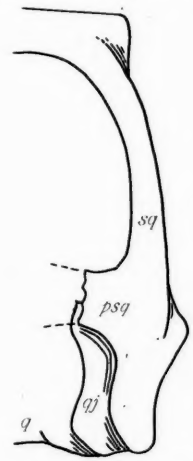

FIG. 5. Edaphosaurus pogonias. Side view of temporal region. *sq*, squamosal; *psq*, prosquamosal; *qj*, quadrate; *q*, quadrato-jugal.

Edaphosaurus pogonias. — This genus differs so markedly from the other Pelycosauria, especially in the presence of a cluster of crushing teeth on the inner side of the mandible, that it may have to be removed from the order. There is one point in the structure, however, that must be mentioned. Cope describes and figures this form (Cope '92) as having but a single arch in the temporal region. In common with most of the other types in the collection this specimen has not been cleaned, and the very slightest removal of the matrix showed that there were two temporal arches instead of one. Instead of the lower portion of the suspensorium being formed of a single mass and connected with a so-called zygomatic bone, as

shown by Cope, figure 4, there are several bones, the quadratojugal is broken and crowded under the lower end of the suspensorium, and that there was a distinct process is indicated by a broken stump, which is undoubtedly the posterior end of the prosquamosal arch, figure 5. The position of this arch shows that the upper vacuity was large and rounded and the lower narrow and smaller, perhaps nearly closed, but there were two distinct arches.

Clepsydrops natalis. — The posterior portion of the skull in the type specimen is badly crushed, and the whole specimen is covered with a thin layer of matrix, so that there is much uncer-

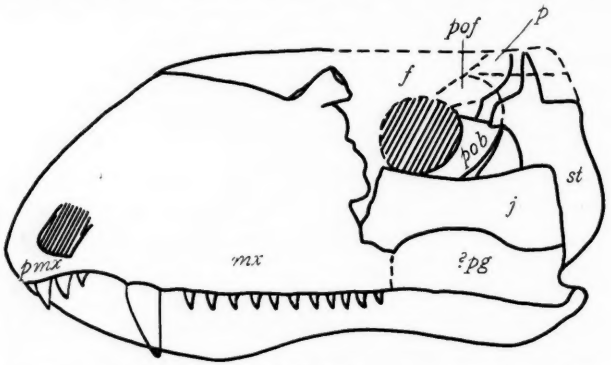

FIG. 6. Clepsydrops natalis. Side view of skull after Cope. *pmx*, premaxillary; *mx*, maxillary; *f*, frontal; *pof*, postorbital; *pob*, postorbital; *p*, parietal; *st*, (squamosal) supratemporal; *j*, jugal; *?pg*, pterygoid.

tainty regarding the exact limits of each bone. The anterior portion of the skull is strikingly similar to the same region in Dimetrodon and Embolophorus in all the characters of extreme specialization such as the high and narrow facial region, the deep diastema and the enlarged canine and incisor teeth so that there is strong presumptive evidence that the posterior arches had an equal similarity. This is further borne out by the very fact of the fractured condition of the posterior angles of the skull, which are almost universally destroyed in the Pelycosauria because of the weak arches. Certain elements of the temporal region can be made out beneath the thin coating of matrix, but these do not seem to me to be what Cope thought them. He

described and figured but a single arch (Cope '78, '92). The portion marked jugal by him, figure 6, is crossed by a break that seems to me to be very likely along the suture between the quadrato-jugal and the jugal. Posterior to the orbit the bones are badly broken and mixed, but certain parts seem capable of a very different interpretation from that of Prof. Cope. The small fragment labeled post-orbital in Cope's figure seems to me to be a bit of bone from the base of the skull extending out of the orbit. Posterior to the orbit Cope has figured but one piece which he calls the supratemporal; this appears different to me inasmuch as the anterior edge distinctly shows the rounded excavation forming the posterior edge of the orbit and indicating

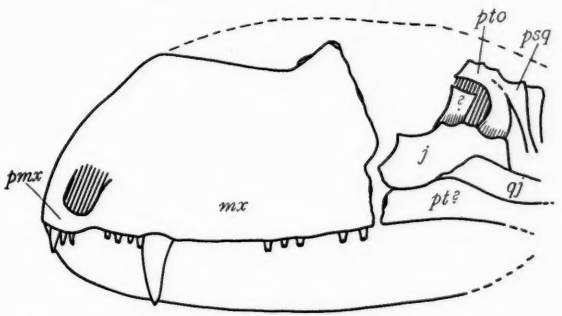

FIG. 7. Clepsydrops natalis. Side view of the skull represented in fig. 6 without any attempt at restoration, as it appears to the author. *pmx*, premaxillary; *mx*, maxillary; *pto*, postorbital; *psq*, prosquamosal; *j*, jugal; *qj*, quadrato-jugal; *? pt*, pterygoid.

that it is the postorbital bone. Further back the mass bifurcates, this would make the anterior leg of the bifurcation the lower part of the postorbital, a consideration which is borne out by its relation to the upper part of the jugal; the suture between the two is hidden by the matrix and a fracture. The posterior leg is exactly in the position of the anterior end of the postorbital-prosquamosal arch if the arches had the same depressed form as in Dimetrodon. These ideas are expressed in figure 7.

Further evidence that Clepsydrops had the same arch structure as in Dimetrodon is found in the greatly elevated neural spines which are found only in the most specialized types. In Clepsydrops they are from eight to nine times the length of the centrum.

For purposes of comparison the figure of the lateral aspect of the skull of Dimetrodon is here introduced to show the most specialized skull of the Pelycosauria. Figure 8.

The relation of the African forms to the American. — Just as the American Pelycosauria passed through a series of specializations which led to extinction so the related African forms (Therosuchia or Therodontia) seem to have passed through a series of stages which promised persistence and which if not leading directly to the ancestry of the mammals at least illustrate by a beautiful example of convergence the method by which the articular region of the mammals might have been developed.

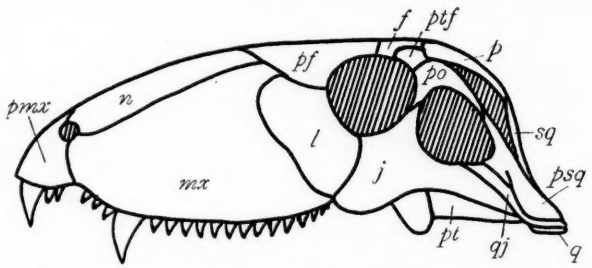

FIG. 8. Dimetrodon incisivus. Side view of skull. *pmx*, premaxillary; *mx*, maxillary; *n*, nasal; *pf*, prefrontal; *f*, frontal; *l*, lachrymal; *ptf*, postfrontal; *po*, postorbital; *p*, parietal; *j*, jugal; *sq*, squamosal; *psq*, prosquamosal; *pt*, pterygoid; *qj*, quadrato-jugal; *q*, quadrate.

The most important steps in the development of the skull structure from a form like Diopeus to such a form as Gomphognathus or Tritylodon seem about as follows:

1. The degeneration to the quadrate and the development of a definite posterior cranial wall by the extension of the parietals.

2. A tendency to the union of the bones of the postorbital and temporal regions to form solid temporal arches.

3. The approximation and union of the two temporal arches to form a zygoma.

4. The union of the posterior end of the zygoma with the prosquamosal portion of the prosquamosal + squamosal and the squamosal portion spreading out as a thin plate closely applied to the skull wall almost at right angles to the zygoma.

5. The development of a mammalian palatal region and a characteristic basipterygoid region from a type similar to Dime-

trodon by the loss of cartilage and the approximation of the posterior portions of the pterygoids and the basioccipital and basisphenoid bones.

6. The development of the bipartite occipital condyle.

Among the American forms there seems to be none which approach the condition of a single zygomatic arch; among the African forms none has been discovered which shows the two temporal arches at all perfectly.[1] The nearest approach to the Rhyncocephalian condition is in Procolophon and Cynognathus, as the structure of these two clearly indicate the previous possession of two arches we may assume the existence of a Diopeus-like ancestor as indicated above.

I select as examples to illustrate the above conclusions Cynognathus, Galesaurus and Gomphognathus because they are the best preserved and described forms and because they are typical of the three fairly distinct groups, the Cynodontia, Lycosauria and Gomphodontia. All of these have the well developed occipital crest and cranial wall, but show the advancing stages of development in the arches and certain changes of importance in the teeth.

In Cynognathus the postorbital and postfrontal have united and developed posteriorly parallel to the jugal. The jugal bar reaches far back and comes in contact with the inferior portion of the united prosquamosal and squamosal (psq + sq) figure 9. The quadrato-jugal is probably crowded beneath the lower end of the psq + sq as indicated below. The union and strengthening of the bones of the two arches is accompanied by an approximation of the two arches leaving only a small inferior temporal vacuity between the two and by the suppression of the quadrate. The psq + sq is described by Seeley (Seeley '95) as a thin plate bent upon itself nearly at right angles, the point of the angle extending outward and forming the posterior angle of the skull. The inner half of this plate, squamosal portion, lies closely applied to the cranial wall, and the outer, prosquamosal portion, forms the posterior part of the upper half of the composite temporal

[1] In all probability Saurosternon, Huxley, possessed the two temporal arches, but it is primitive to the forms discussed in this paper. It may occupy a position similar to Theropleura among the American forms.

bar. Seeley describes a vertical channel marking the outer side of the angle of the psq + sq persisting downward to the point

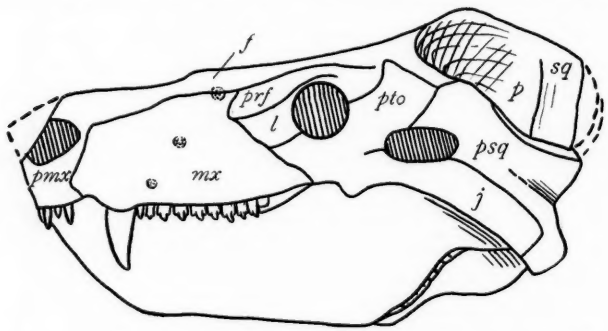

FIG. 9. Cynognathus crateronotus. Side view of skull. *pmx*, premaxillary; *mx*, maxillary; *f*, frontal; *prf*, prefrontal; *l*, lachrymal; *pto*, postorbital; *p*, parietal; *sq*, squamosal; *psq*, prosquamosal; *j*, jugal. After Seeley.

where the bone expands to cover the quadrate, this groove probably marks the point of union of the squamosal and prosquamosal.

The quadrate is figured by Seeley (figure 10) as a flattened bone with two ascending bars beneath the psq + sq, the two bars show through an evident breaking away of the thin plate of the covering bone. At the same time it is noticeable that the outer part of the lower edge of the psq + sq comes in contact with the articular. Seeley describes the first of the vertical bars as "distinct from the quadrate below and the squamosal above with which it is in close contact"; the same fact is expressed by a line on the quadrate separating the lower part from the portion bearing the vertical bars. It seems very possible that this upper portion is the lost quadrato-jugal which does not appear on the side of the skull.

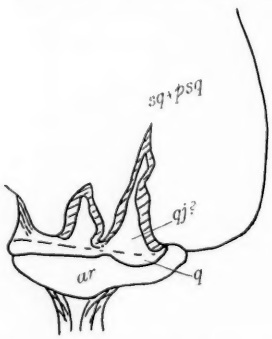

FIG. 10. Posterior view of temporal region of Cynognathus. *sq* + *psq*, squamosal + prosquamosal; *qj?* quadrato-jugal; *q*, quadrate; *ar*, articular. After Seeley.

In Cynognathus the palate is typical reptilian, the teeth have only small lateral tubercles and the whole dentition resembles that of Dimetrodon in the large incisors and canine, the sharp diastema and the convex tooth line.

In Galesaurus and in Cynognathus platyceps there is a single temporal arch with no trace of an inferior temporal vacuity. The bar is formed of two parallel bars, one above the other, with no indication of distinct bones forming each bar. The lower of these bars is called by Lydekker (Lydekker '90) the quadrato-maxillary and the upper the squamoso-maxillary; if the condition of this form is derived from a condition represented by Cynognathus crateronotus the lower bar is really the jugal, the quadrato-jugal having disappeared beneath the psq + sq and the upper bar is the prosquamosal + postorbital. As the prosquamosal is already united with the squamosal, there is now a single mass, the postorbital + prosquamosal + squamosal. Seeley points out that in Galesaurus the lower portion of the psq + sq descends below the quadrate posteriorly.

In Galesaurus the palate approaches the mammalian condition found in the Gomphodontia and the teeth have strong lateral tubercles. The diastema has almost entirely disappeared though there is still a prominent canine.

In Gomphognathus the temporal region is much the same as in Cynognathus, the region is described as follows by Seeley (Seeley '95) "the squamosal rest upon the parietal as a thin film, which descends laterally to the level of the occipital condyles, when it makes a sudden angular bend upward and outward.

The lateral contour of the ascending bar of the squamosal bone is convex, and nearly at right angles to that of the lateral border of the occiput; both are equally thin, and the two plates define a V-shaped squamosal notch which is open superiorly. But the squamosal bone is much more massive than is at first obvious, and below this thin external posterior plate, there is an excavation in the bone, which shows it to be expanded laterally for 1 $\frac{3}{4}$ inch beyond the compressed ridge at the base of the V-shaped fold just described."

The squamosal described by Seeley is of course the psq + sq of this article; the prosquamosal portion forms the posterior part of

the zygoma and its anterior end is wedged into the posterior end of the jugal. In front, the edge of the temporal vacuity is formed by the jugal externally and the postfrontal internally. The prosquamosal bar no longer lies parallel to the jugal bar; the jugal bar no longer extends far back to articulate with the prosquamosal near the suppressed quadrato-jugal, but the two bars lie in the same plane and unite in the middle to form a true mammalian zygoma.

In Gomphognathus the mammalian palate is fully developed and the teeth are tuberculated and indicate probably an herbivorous habit.

The significance of the development in the American and African forms.— In a previous paper the author has shown that it is possible to recognize two lines of development in the temporal region of the reptiles. The forms showing the two lines were described as the mastocephalous and saurocephalous groups (Case '98) as follows: "From this point (the Proganosaurian condition, Diopeus[1]) onward the Reptilia are divided into two groups, one with an elongate quadrate, which includes all the modern and most of the extinct Reptilia, and one with a depressed quadrate reaching its highest development in the Permian, and in all probability losing its identity in the direct ancestors of the mammalia." It now seems possible to trace a step farther the origin and history of the phyla.

The lower jaw is the movable element in mastication, and in biting it acts as a lever of the third class with the power supplied by the masseter and temporal muscles applied nearer to the fulcrum, represented by the quadrate, than to the weight, represented by the substance being chewed. It is evident that where the jaws are used for such heavy work as chewing the fulcrum region must be very strong to resist the strain imposed upon it; in the forms which swallow their food without previous mastication, as the Pythonomorpha and Ophidia, and the Amphibia in large measure, there would be little need of resist-

[1] In the article quoted I stated that the generalized ancestor of the *Pelycosauria* had not yet been discovered, it now seems probable that that stage of evolution is represented by Diopeus, which will be seen from the description given above to fill the necessary conditions.

ance in the quadrate region, and in all these forms it is notably weak. The development of a chewing habit, either grinding or sectorial, would bring a greatly increased strain upon this region. We know little that is definite concerning the origin of the temporal and quadrate region in the reptiles next above the Cotylosauria, but as Baur has shown, this may well have developed by a sort of natural trephining of the solid cranial roof, perhaps in response to the demand for a lighter skull connected with changing feeding habits, and resulting in the Proganosauria.[1]

In the Proganosaurian skull the quadrate was well developed and had much the same position and proportions as in the modern Sphenodon, but was of slightly less vertical extent. As indicated by the character of the teeth these forms used the jaws very little if at all for chewing. The beginning of a chewing habit, either sectorial or the simpler kinds of crushing or grinding, would demand a simple vertical motion of the jaws, with a consequent demand on the quadrate to resist a stronger thrust directed vertically upward. The shape and character of the articular surfaces of the quadrate and articular bones in some of the American forms, as in Dimetrodon, make any other motion than a vertical one impossible.

The strengthening of the temporal and quadrate regions to resist the increased vertical strain was accomplished in two ways: First by an enlargement of the quadrate, especially in the vertical direction, and its closer union with the skull wall; this was accompanied by a decrease in the number of bones in the temporal arches and an enlargement of those remaining (compare the condition in the Squamata and Testudinata). Second by a reduction in the size of the quadrate till it finally disappears (in the mammals or Promammalia) and at the same time a union of the bones of the temporal arches till the articu-

[1] In this connection it is of interest to note that the author discovered perforations in the roof of the skull of the Diadectidæ in the Cope collection in the position of the superior temporal vacuities, the forms are too specialized to make the interpretation of this occurrence certain, but it may well be the first step toward the Proganosauria type. In the line of the argument of this paper it is also interesting to note that the Cotylosauria all had strong, crushing, or grinding teeth and strong quadrate bones firmly enclosed in the roofing bones.

lation of the lower jaw finally comes at the base of a strong buttress formed by the coössified bones of the suspensorium.

The second of the two processes, described above, was attempted in two different ways. The flattening of the quadrate was common to both, but the supporting temporal arches were disposed of very differently. In the American Pelycosaurians the bones of the temporal arches all retained their identity and remained distinct one from the other, but the posterior ends of the bones followed the quadrate down in its degeneration until the angle of the skull was depressed and the arches were long and slender; compare figures 3 and 8. This made a very weak suspensorium especially as the opisthotic, the single bone which connected the quadrate directly with the skull wall was separated from it by the intervention of considerable cartilage. When the jaw was compressed on food in the act of biting, the strain on the quadrate region would be directly upward, but instead of this strain being met by bones arranged to meet it parallel to their length and firmest attachment, as in the modern lizards, or against bones solidly united and joined to the brain wall, as in the mammals, it was directed almost at right angles against the free ends of slender bones at a point fartherest removed from their attachment to the skull. Such an arrangement was clearly unadapted to resist the strain imposed upon it by the force of the fierce bites these animals were capable of inflicting. As shown above, the advance in the slenderness of the quadrate region kept pace with the advance in the development of the carnivorous habits as evidenced by the increase in size of the incisor and canine tusks and the serrations of the cutting edges of the teeth; the latter speaking of a growing habit of sectorial mastication. The two processes working in opposition.

In the second line of changes that centered around the depressed quadrate there was a decided tendency to a coalescence of the bones of the temporal region; thus the postfrontal and the postorbital were frequently united, the squamosal and prosquamosal the same and the quadrato-jugal either became united with the posterior end of the jugal or, more probably as shown below, disappeared beneath the lower end of the psq + sq. After the union of the individual bones the two arches

united, first partially (Cynognathus crateronotus and Procolophon) and finally completely (C. platyceps and Galesaurus). Notable is the position assumed by the squamosal portion of the psq + sq; as shown above in the description of the forms it is spread out as a thin film upon the surface of the cranial wall formed by the developing of the parietals, so that it was firmly held by its application to the skull wall as in the mammalian temporal and is free only at its lower extremity. From this free extremity of the squamosal portion the prosquamosal portion extends forward almost at right angles, the quadrate and quadrato-jugal are probably concealed beneath the point of union of the two and the quadrate is so far overwhelmed that the lower end of the psq + sq comes into articular compact with the articular.

This structure perhaps presents the best mechanism to resist the strain imposed upon the quadrate in biting; it is straight up against the lower end of a bone fastened to the skull by nearly its full length and its parallel to the strongest attachment. That the forms in which it occurs had strongly developed biting habits is evidenced by the tuberculated teeth and the herbivorous grinding teeth of the Gomphodontia.

If the reasoning presented here is correct it is possible to recognize two phyla among the Permian Pelycosauria; one characterized by the persistence of the two Rhyncocephalian arches and the development of a weak articular region, culminating in the high-spined Pelycosauria and the other characterized by the union of the arches and the development of a mammalian temporal region culminating in Gomphognathus and Tritylodon, perhaps in the Promammalia. The last branch practically includes all of the Theriodontia = Theriosuchia.

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NOTES ON THE UNIONIDÆ AND THEIR CLASSIFICATION.

V. STERKI.

THE Unionidæ are not only the most conspicuous invertebrates of our fresh waters, and wonderfully rich in species, but they are also very interesting morphologically and physiologically. The publication of Simpson's synopsis of the Naiades, made a new era in our knowledge of these animals. On the one hand, Simpson has undertaken the important and difficult task of revising the enormous number of described species by the careful examination and comparison of an immense mass of material. A large number of nominal species have been referred to those which were believed to be valid, when reduced to synonyms and varieties. On the other hand, he has shown that not only the shells, but principally the soft parts, must be considered in order to build up a proper classification and he has investigated and sifted the attempts of earlier writers in that direction.

Having studied for years such of our Unionidæ, or, more properly, Unioninæ, as were obtainable, their soft parts, propagation, and embryos, I have formed some ideas of my own regarding their classification, which proves to be somewhat at variance with that given by Simpson. At first it seemed preferable to wait, and study and compare further,[1] until now, almost two years later, I feel more satisfied than ever that these views have a real foundation and some scientific value.

The Glochidia.— It has been found long ago, especially by Isaac Lea, that there are considerable differences of shape in the shells of the embryonic young of Unionidæ, but, so far as known, no attempt has been made to apply this fact to classification. The phases and changes of early and embryonal life are more and more regarded as important in estimating the system-

[1] Many living specimens of different groups and species were kept under observation for shorter or longer periods.

atic position and phylogeny of all groups of animals, and must be taken into account in studying the Unionidæ. Since differences between embryos seem to be correlated with circumscribed groups of the adult animals, they must be regarded as a valuable factor in classification. The writer has examined embryos of many species at different stages of development, not only in regard to the shells but also to the soft parts showing decided and interesting differences between the several groups and species.[1] There are three main types of glochidia, so far as known:

1. Those of Anodonta, Alasmidonta, etc. — Their valves are large, rounded-triangular, with a long dorsal commissure, a strong thickening along the margins, and are pointed in the middle of the ventral side, each bearing a large, rough spine, or "hook" (spur) bent inward so as to prevent the closing of the shell, which remains wide open during the embryonal stage of life. This formation is of decided importance, morphologically and physiologically, for doubtless these strong spines facilitate the attachment of the young mussels, after being discharged from the branchiæ of the parent, to the fins, etc., of fish, and possibly to parts of other aquatic animals. It is to be regretted that so little is known in regard to the early postembryonal life of the young Naiades.

2. Those of Proptera, e. g., alata Say. — The dorsal commissure is short, the dorso-ventral diameter being the largest; the ventral margins are rather short, truncated or slightly curved; there is a smooth spine at the anterior and posterior ends (of the ventral margins) of each valve, bent slightly outward and by passing those of the opposite valves, allows the shell to close along the ventral side. The long anterior and posterior sides are truncate, nearly straight, and the shell is widely gaping at both ends, a feature which is permanent, to a degree, in the adult shell.

3. The glochidia of those species which were generally ranged under the old genus Unio, with the exception of Proptera, have a moderately long dorsal commissure, and are generally rounded

[1] It is intended to publish the results of these investigations when they are more advanced.

along the other margins, but otherwise of various shapes, the dorso-ventral diameter (properly altitude) showing considerable differences. There are no spines, the margins of the valves are simple, or nearly so, and the shell can be entirely closed. There are minor differences in the configuration of the shells and the soft parts.

The Hinge. — The species of the old genus Unio, with few exceptions, have perfect [1] hinges, and this seems to be a feature characteristic for the whole group, and is of systematic importance.

In the species ranged under Anodonta, Alasmidonta, etc., on the other hand, the hinges are generally more or less deficient, or wholly wanting. *Symphynota pressa* Lea (*Unio pressus*) is a real, or apparent, exception, it having rather perfect but feeble hinge teeth. Other features of the shell, the soft parts and the embryos, show relationships with Symphynota, such as *S. costata* Raf. Natura non facit saltus.

In this connection should be mentioned the genus Margaritana, some species and varieties of which have perfect and others imperfect hinges, in adult specimens.

The muscles, especially the large adductors, are generally of a different color and texture in the Alasmidonta-Anodonta group than in the "Uniones."

The Marsupia. — It is now generally known that there are two different types of embryo-bearing branchiæ, or parts of such. In Anodonta, Alasmidonta, etc., and in a part of the Uniones (in the older, wider sense) the ova and embryones are lodged only in the outer, or all four branchiæ, which, when not gravid, are of the ordinary formation and appearance. In another group of the Uniones, the marsupia are not only invariably in the outer branchiæ, but also permanently differentiated, so that they may be recognized even when not gravid. They are located in certain parts of the branchiæ, in most species, with approximately fixed numbers of ovisacs for each species, or extending over the outer branchiæ through their whole length, as in Ptycho-

[1] Only as regards the hinges of the Naiades and not in a general sense; the hinge-type of the Cycladidæ, for example, is more perfect, and more constantly so.

branchus; but in the latter genus also they are permanently differentiated in the female.

This fact has possibly not been given due weight, and Simpson has been severely criticised for giving systematic values to physiological features. This character, however, is distinctly an anatomical one, and must be regarded as a factor in classification.

It is well known that in some of the Quadrula all four branchiæ bear ova, or embryos, but it has not been proven that this is so in all, especially in younger specimens, such as *Q. pustulosa* Lea, etc. Neither is it known whether in some species of Unio and Pleurobema the same condition may not be found occasionally. Moreover, Simpson himself says that in *Anodontoides ferussaciana* all branchiæ have been found bearing ova, and Gysser makes the same statement in regard to *Margaritana margaritifera*. This clearly shows that a distinction between two groups cannot be founded on this feature, the more so, since such closely allied forms as Unio, Pleurobema, and Quadrula are separated.

Differences of Male and Female Shells. — For some groups, these differences have long been known, most of the genera Lampsilis and Truncilla being familiar examples. The distension of the female shell near the posterior-inferior end — as a rule — is obviously the result of the demand for space for the voluminous gravid marsupia near the posterior ends of the outer branchiæ. These differences are of various kinds and of very various degrees, as especially among the Truncillæ, not only between different groups but also between species of the same groups, and even between different local forms of one and the same species, *e. g.*, *Lampsilis luteolus* Lam. There are even species where we can speak not only of a *distension* in the female, but of a *different formation* of the entire shell, as in *Plagiola securis* Lea. In other forms the differences may be very slight, as in *Obov. ellipsis* Lea, although its marsupia are of the same type with those of *Lampsilis ventricosus* Barnes. The members of the genus Ptychobranchus though having voluminous, and highly differentiated marsupia, show no outward differences of the shell, and some females may be even less inflated than males of the same size, as has often been observed by the writer. However, there is a

difference of another kind: a deep, oblique sulcus on the inside of each valve, in the female, the space occupied by the marsupium, so that the sexes can readily be distinguished on the empty shells at least in older specimens.

It may be repeated here that in younger examples of Lampsilis, etc., the female shells cannot be distinguished from the males during the first two or three years of life, and the distension is formed only from that age on, with the development of the marsupia.

The female shell of *Tritogonia tuberculata* Barnes, is less inflated posteriorly than the male, and has a flat, thin extension at the posterior end. Here the difference is of another kind than in Lampsilis, a small portion of the branchia, if any, finding room in the extended part of the shell, the genus evidently ranging under another group: with Unio (s. str.), Quadrula, etc., without differentiated marsupia.[1]

In some species of Unio, Quadrula, etc. there are slight, more or less marked differences between the male and female shells, the latter being, generally, more inflated, and sometimes differing in outline so that the sexes can be recognized with some reliability. Yet these differences are not so typical and so constant as in Lampsilis, Tritogonia, etc.

Species of another group, however, show well-marked differences, *e.g.*, *Alasmidonta truncata* H. B. Wright[2] and *A. calceola* Lea. The fact was well known to the older conchologists, and even the late Hy. Moores, three fourths blind, readily discerned the sexes by a touch. The females are more inflated and more voluminous posteriorly, curved down, and having generally a stronger ridge. It is much the same with *Strophitus edentulus*

[1] So far as known, this species has not yet been seen in the gravid condition. Its branchia, however, show no differentiated parts, and are barren during fall and winter, while the ovaries are charged with ova and the testes with sperm, as in Quadrula, etc., which Tritogonia closely resembles in its soft parts and shell. In dissecting a large female, I found a number of thin, grayish, beaded strands, of various lengths, scattered in the outer branchiæ, in all probability rows of abortive and degenerated ova. The strands were between the branchial fibrillæ and parallel with them.

[2] The name is the one given in Simpson's *Synopsis*. Since then it has been asserted by Fox that the Western form is the true *Al. marginata* of Say. (See *Nautilus*, vol. xv, pp. 16, 47.)

Say, and the sexes can generally be recognized by the shape of the shell; and the same may be said of *Symph. costata* Raf. (*rugosa* Barnes).

We have, then, among the Unioninæ with differentiated marsupia, species in which the female shells are decidedly different from the males, others in which they are slightly so, and still others where differences are not recognizable. Those without differentiated marsupia mostly show slight or no such differences, while in Tritogonia, though of another type, it is well marked; and again there are marked differences between male and female shells among the Alasmidonta, etc. It is evident from these facts that much weight cannot be placed on this feature for purpose of classification. If so, natural groups would have to be divided, and discrepant forms united.

The Inner Branchiæ. — The upper edges of the inner branchiæ are adherent to the abdominal sac either immediately, or by an interposed soft membrane of varying width. In some genera, or species, even in the same individual a part of the branchiæ may be of one, the balance of the other type. Simpson has paid considerable attention to this feature, and it seems that there are no constant differences available for classification.

Seasons of Propagation. — Since the publication of my observations several years ago, I have been able fully to confirm the facts then stated. The forms with differentiated marsupia, as Lampsilis, Ptychobranchus, etc., bear embryos during the fall and winter, and discharge their young in spring and early summer, rarely a part of them in autumn. The same was found to be true with the Alasmidonta, Symphynota, etc. On the other hand, the Unio (s. str.), Quadrula, Tritogonia, etc. were invariably found with the branchiæ barren during fall and winter, their ovaries filled with ova and the testes with sperm. This shows that Lampsilis, etc., bear their young during a long period, about eight or nine months. With Unio, etc., the charging of the branchiæ with ova, the development and discharging of the young is all effected within a few summer months. We may properly designate the latter as summer breeders, the former as winter breeders.

This is a purely physiological feature, and, moreover, is proved

only for the animals living in this latitude. But being coincident to a considerable degree with anatomical characters, it certainly is significant, and seems to have some bearing on the phylogenetic origin of these groups, as stated elsewhere. It appears to point to different climatic conditions under which the several groups developed and differentiated from their ancestors.

Reviewing the points discussed above, we find the principal natural divisions as follows:

1. The forms with perfect hinges, typically and generally Their embryonic shells are not pointed in the middle of the ventral margin, and able to close.

2. The forms more or less deficient in, or lacking, hinges, typically and generally. Their embryonic valves are subtriangular, pointed on the ventral side, and each bearing a large spine.

Each of these main groups seems to contain the forms nearest related. Any other arrangement would separate naturally allied forms and unite incongruous ones.

There may be one exception, however, as pointed out above, and that is the genus Proptera. In the members of the genus there are a number of features at variance with those of group 1, *i. e.*, the thin shells; the dorsal wings, anterior and posterior to the beaks; the gaping in front and behind, probably the umbonal sculpture; the slight, and in some species, even deficient hinges. Adding to these the very different form of the embryos, we have a collection of characteristics which place these molluscs not only in a generic rank of equal standing with that of Lampsilis plus its nearly related genera, but as a group by itself. In my opinion they rather represent a third main division between those of Lampsilis-Unio and Alasmidonta-Anodonta. On the other hand they have one characteristic in common with Lampsilis, etc., *i. e.*, the differentiated marsupium, consisting of distinct ovisacs. Whether this feature should be regarded as paramount in contrast with all the others mentioned, may be questioned. For the present, however, I prefer to range them alongside of those which have been regarded as their relatives.

Judging from certain features, there is some similarity between Proptera and Pseudospatha Simpson, in regard to the shells, and

it will be interesting to compare their soft parts and embryos, when obtainable.

If designations are wanted for the main divisions, they might be called: (1.) Holodontes, (2.) Haplodontes.

The former again contains two main subdivisions, — one in which the marsupia are differentiated, the other in which they are not so. Among the first, Ptychobranchus represents a group by itself, equivalent to the balance, owing to the exceptional formation of its branchiæ and ovisacs, and features of the shell. A group represented by *C. irrorata* Lea, *reflexa* Raf. and *dromus* Lea seems a natural one, although there are differences in the number and size of the ovisacs, which might be regarded as sufficient for generic distinction. And so it is with the balance, of which Lampsilis is the typical genus. The differences between male and female shells in the several groups of Truncilla are more considerable than between some of the Truncilla and Lampsilis s. str., and so it is in regard to some other features.

Simpson ranges under the Lampsilis group also Cristaria Schum. and Pilsbryoconcha Simpson, the hinge teeth of which are defective or almost wanting, and the soft parts unknown, as are also the embryos. With a knowledge of the latter, their position will be more fully ascertained. In regard to Pseudospatha we refer to what has been said above.

In the second subdivision of the Uniones, Tritogonia is distinguished by its shell. Unio, Pleurobema and Quadrula, constituting a very large and conspicuous part of our fresh-water bivalves, and comprising various plastic and variable forms, are so closely related and almost inseparably connected, that even the highest authority is in doubt under which of these genera certain species should be ranged. In regard to the branchiæ, we refer to what has been said on p. 108.

It may be in place here to mention that these mussels quite generally are not able to open their shells as wide as the Lampsilis, etc., do. And this seems to be in close connection with the fact that their posterior mantle openings, especially the branchial, are much less fringed than those of Lampsilis, the fringes having the function of rakers, preventing the entrance of coarse materials with the inward current of water, as has been seen by

actual observation, *e. g.*, on *L. ventricosus*. Whenever any larger object touches the margin of the mantle, that is the long and partly branched fringes, they at once move inward and by interlacing form a fine network. Some other species also, *e. g.*, *C. irrorata*, with the valves not opening wide, have the papillæ only moderately developed.

The systematic position of Margaritana is still uncertain. In shape and appearance of the shell, and nacre, they resemble more Unio, than Alasmidonta. The hinge is perfect in some and defective in other species, in what seem to be individuals, typically perfect, and in younger specimens. It has been mentioned that Gysser occasionally found all four branchiæ charged with ova, and in all probability they are summer breeders, like Unio, etc. That, however, must be ascertained by actual observation. The crucial test will be found in the examination of the embryos.[1] — I have also seen in some specimens of *Quadrula kirtlandiana* Lea, very numerous, crowded, small muscle scars scattered over the inner surfaces of the valves inside the pallial line, described as characteristic for Margaritana.

The second main division consists of Alasmidonta, Anodonta and their allies, and these two genera seem to represent the two main groups. Among the former, *Strophitus edentulus* Say, shows a somewhat exceptional feature, which may entitle it to generic rank. As regards the shell, soft parts and formation of embryos, it stands very near to Alasmidonta, but the ova and embryos are imbedded, in various numbers, about from ten to twenty, in cylindrical albuminous masses placed transversally in the outer gills. In my opinion, these masses, which have also been compared with and called placentæ, are not homologous and equivalent with the ovisacs of Lampsilis, etc. The question deserves more study and comparison.

Some other species and genera, *e. g.*, *Lastena lata* Raf. need more examination, in order to ascertain some of their characteristics and their exact systematic positions.

The following table, based upon what is written above, will

[1] I should be glad to receive not only whole specimens, but gravid gills, or parts of such, in alcohol, or even dried, of *Marg. margaritifera* Linn. and *M. mondonta* Say. f.

show more plainly a systematic arrangement which appears natural and logical. It is not carried out to all the genera as established and recognized by Simpson, but only to groups showing characteristic, distinctive features. Again it may be pointed out that Proptera, possibly with an additional genus, might be regarded as representing a third (*i. e.*, the second) main division.

I. Hinge typically perfect; embryonic shell with the ventral margin rounded or truncate, able to close.

A. Marsupia permanently differentiated in the outer branchiæ (winter breeders).

1. Shell without dorsal wings, not gaping at the anterior and posterior ends; embryonic shell without spines, with rounded ventral margin, closing all around.

a. Marsupia occupying part of the branchiæ.

aa. Marsupia near the posterior end of the branchiæ, bean- or kidney-shaped; female shell usually distended near the posterior-inferior end; typical genus: . . . . . Lampsilis

bb. Marsupia occupying almost the whole margin of the branchiæ, or a part near the middle; shell short, heavy; female shell not markedly different from the male; typical genus: . . . . Cyprogenia

b. Marsupia occupying the whole branchiæ forming folds when gravid; shell elongated, not externally different in males and females; . . . . . Ptychobranchus

2. Shell with anterior and posterior dorsal wings (at least in younger specimens), gaping in front and behind; hinge teeth feeble or defective; marsupium in posterior part of branchiæ; embryonic shells with spines at anterior and posterior ends of truncate ventral margin, widely gaping at the truncate anterior and posterior ends: . . . . . Proptera

B. Marsupia not differentiated, the outer, or both pairs of branchiæ serving as brood pouches (summer breeders).

1. Female shell with a flat extension at the posterior end; shell with crowded warts all over: . . . . . Tritogonia

2. Male and female shells slightly or not different; typical genus: Unio

II. Hinge typically more or less defective or wanting; no differentiated marsupia; embryonic valves rounded-triangular, pointed on the ventral side, each with a large spine.

A. Hinge more or less defective (rarely perfect, but feeble); beak

sculpture usually consisting of simple, concentric ridges; male and female shells more or less different.

1. Ova and embryos imbedded in cylindrical albuminous masses lying transversally in the outer branchiæ: . . Strophitus

2. Ova and embryos free in the branchiæ; typical genus: Alasmidonta

B. Hinge teeth wanting; beak sculpture of undulating or two-looped ridges, (animal, at least in some species, hermaphroditic); typical genus: . . . . . Anodonta

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE, E. L. MARK, DIRECTOR.— No. 139.

A PARAFFINE BATH HEATED BY ELECTRICITY.

E. L. MARK.

Under the stimulus of disastrous explosions of gas in other museums and some unpleasant experiences in our own, it was decided somewhat over a year ago to replace, as far as practicable, heating by gas in the Museum laboratories with heating by electricity. The greatest danger from the use of gas is incurred where two or more lights are kept constantly burning in the same room. All of our constant burners for heating water-baths, warm ovens, etc., have been for many years supplied with the Koch automatic cut off, so that in case of accidental extinguishing of the flame, the cooling down of the burner would automatically shut off the gas supply. But the lever of the Koch burner will not always work, even though loaded with a weight greater than that which it carries when it comes from the maker; moreover, the metal, on the expansion and contraction of which the tripping apparatus depends, after a time loses to a certain extent its expansive properties, so that it fails to release the lever and cut off the gas.

The Departments of Botany and of Zoölogy were already in possession of a number of copper water-baths for heating paraffine and warm ovens of various constructions, which it was desirable to retain if they could be provided with a suitable electric heating apparatus. With the aid of suggestions from Professor Sabine of the Department of Physics and the coöperation of constructors of electrical apparatus, a plan was finally worked out which answers fairly well the requirements of the ordinary paraffine water-baths.

There were two chief problems to be solved: first, to ascertain the minimum heating capacity of the heating coil necessary for each bath; secondly, to devise an automatic regulator to control the electric heating current. To reduce the amount of heat lost, each bath was provided with a felt jacket,— covering all parts except the top,— enclosed in a canvas cover. The felt was about half an inch thick, and the canvas cover after

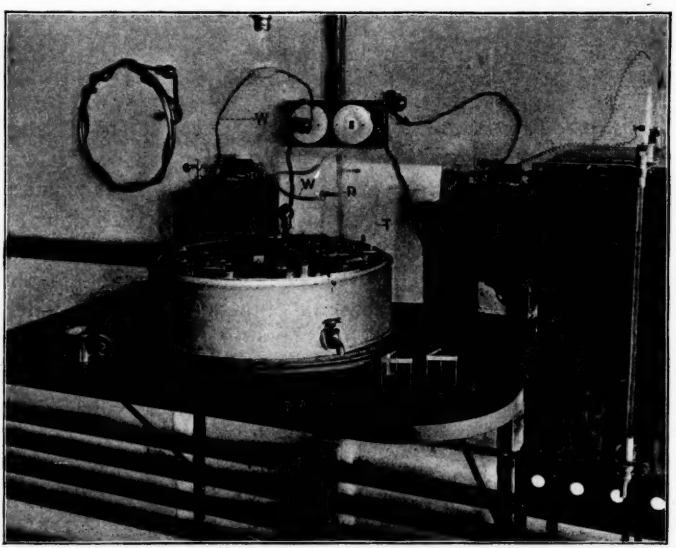

FIG. 1.— Paraffine water-bath and automatic electric heating apparatus. The 150-ohm telegraphic relay apparatus is mounted on the top of box containing a one-cell battery. Plug in place in the receptacle. At the right the plug of another heating apparatus removed from receptacle and hung on a hook. At the left a detached heating coil and insulated wire cable hanging on the wall. *R.*, regulator; *T.*, thermometer; *W.*, wires of heating circuit; *W'.*, wires of relay circuit.

being slipped over the felt was laced up on one side, as is shown above the faucet in Figure 1. The manufacturers of the heating apparatus employed (the Simplex Electric Co. of Boston and Cambridge) then determined empirically the proper resistance and length of coil required to maintain a given temperature in each of the different forms and sizes of baths. To insure uniform distribution of heat, the coil should make at least one whole

turn. As constructed for our paraffine baths the coil is a somewhat flexible cylinder, about half an inch in diameter, with copper covering. With its attached insulated wires such a coil is shown hanging on the wall at the left in Figure 1. The resistance metal used in the coil was a copper-nickel alloy. In the case of the paraffine baths this coil was simply shoved into the bath through an inch hole made in the top of the bath. The knob with connecting wires protrudes outside, and the coil rests on the floor of the bath, immersed, of course, in water. In the case of the thermostats used for incubating purposes, etc., a hole was cut in the side or bottom of the water reservoir, and the coil after being introduced was soldered in place so as to close the hole.

To devise a regulator was more difficult. The use of an ordinary rheostat proved to be impracticable, because it was not possible to make sufficiently fine gradations of resistance for different temperatures, nor by it to provide against fluctuations in the initial current.

The method finally adopted utilizes a one-cell relay battery to magnetize an electro-magnet. The heating current is made to pass through the armature, which is pulled into contact with a vertical post by means of a delicate spring. When the armature is drawn away from the post by the magnet the heating current is broken. Into the circuit of the relay battery is put the regulator; when the relay circuit is closed at the regulator, the magnet operates on the armature and breaks the heating current; when the relay circuit is broken at the regulator, the armature is drawn back by the spring to its first position thus closing the heating circuit.

Our Reichert gas regulators (*R*), already in use for the purpose of regulating the *gas* supply to the burners, were adapted by very slight changes to the new requirements. The tubular glass stopper carrying the gas inlet was removed; in its place was put a cork, bored to receive one of the copper wires (*W'*) from the single-cell battery of the Leclanche type (Samson cell No. 2). The copper wire terminates with a No. 20 platinum wire (Fig. 3, *Pt.*) which is about an inch long; the height of the lower end of this wire above the mercury in the column can be

roughly adjusted by moving the copper wire through the cork and wedging it in place by a small wooden wedge occupying with the wire the hole in the cork. The contact of the mercury with the platinum wire serves to close the circuit of the battery, the other wire from the battery being connected to the mercury by means of the screw and piston in the side tube used to adjust the height of the mercury column. Into this single-cell circuit is put a standard 150-ohm telegraphic relay machine of the pattern used by the Western Union Telegraph Co.

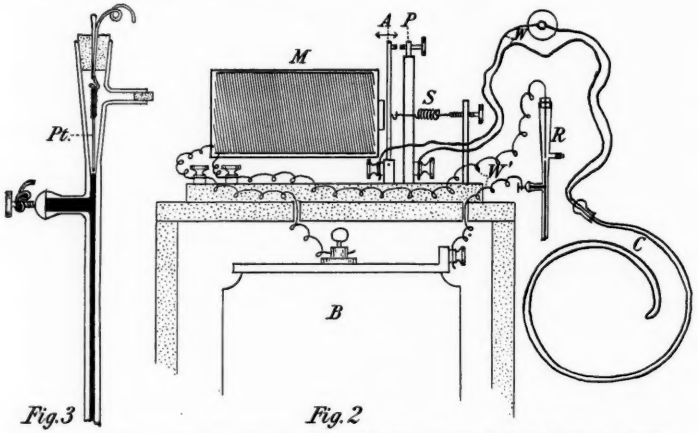

Fig.3 Fig.2

FIG. 2. — Diagram to show the connections of heating coil and circuit with relay battery, electro-magnet and mercurial regulator. *A.*, armature; *B.*, battery; *C.*, heating coil; *M.*, electro-magnet; *P.*, post in the heating circuit: *R.*, regulator; *S.*, spring; *W.*, wire of the heating circuit; *W'.*, wire of the relay circuit.

FIG. 3. — Upper part of mercurial regulator — Reichert's gas regulator modified — drawn to larger scale than in Figure 2. *Pt.*, platinum wire.

The closure of this single-cell circuit magnetizes the core of the electro-magnet (*M.*), which, pulling against the delicate spring (*S.*), overcomes it and moves the armature (*A.*) away from the post (*P.*), thereby *breaking* the heating current.

When, owing to the interruption of the heating current, the bath cools, the mercury in the regulator recedes from the platinum point, thus breaking the *relay* circuit, the electro-magnet becomes demagnetized, and the delicate spring pulls the armature into contact with the post and thus closes the *heating* current. The finer adjustment of the distance between platinum point and

mercury in the regulator is effected, as in gas regulation, by the screw and piston working on the mercury in the horizontal arm of the regulator.

The points on armature and post at which the heating current (110 volts alternating) is made or broken require to be made of heavy platinum wire (No. 15), for otherwise there is danger that the metal will fuse.

The paraffine baths of the form shown in Figure 1 are about 19 inches in diameter and 5 inches deep. The current required to heat such a bath is approximately equal to that of four 16-candle-power lamps. This could be much reduced by enclosing the bath in a glazed frame, one side of which would have to be movable to permit access to the cups.

The whole apparatus, except the heating coil, was furnished and installed by Clark & Mills, 23 Church St., Cambridge, and 543 Boylston St., Boston. It cost, including the heating coils, between $25.00 and $30.00 for each bath.

In determining the resistance to be used in the heating coil, one should make it as low as possible consistent with the maximum heating capacity required; for with greater heating capacity the heating current will be in operation a shorter time than with less heating capacity, and consequently the *relay* current — which is in operation whenever the heating current is not — will be required to work longer, and therefore the battery will become exhausted sooner. When the battery is so far exhausted that it will no longer magnetize the core sufficiently to overcome the spring and break the current, the regulation fails and too high a temperature results. However, a single cell will, with proper care, last for several months without renewal. To guard against the danger of too weak a relay current, one should test the current from time to time with a voltmeter.

There is one difficulty with this mercurial regulator, due to the oxidation of the mercury at the time of making and breaking the relay current. This in time causes a deposit on the platinum wire of oxide, which acts as an insulator and thus prevents sharp contact. The deposit may be removed, however, by immersing the platinum wire from time to time in weak nitric acid, and if a layer of high-test kerosene oil covers the mercury in the regulator the oxidation may be prevented.

NOTES AND LITERATURE.

ZOÖLOGY.

Development of Cribrella. — The early development of the starfish Cribrella has been made the subject of exhaustive study by Dr. A. T. Masterman.[1] Segmentation, which is very variable, always culminates in a morula of equal cells. This becomes a blastula, after which gastrulation takes place. The blastopore closes and the archenteron divides into a mensenteron, and an anterior cœlom, and a posterior cœlom. The embryo then escapes as a free ciliated larva. The posterior cœlom becomes the hypogastric cœlom of the post-larval stages. The anterior cœlom becomes differentiated into a central cœlom, and a right, and a left lateral cœlom. The central cœlom becomes the "dorsal sac"; the right lateral becomes the epigastric cœlom; and the left lateral the hydrocœle which eventually gives off five radii. The bilateral larva loses its exact symmetry through an enlargement of its left side. Fixation takes place and the unsymmetrical larva is converted into a young starfish. The larval sagittal plane corresponds to the discal plane of the starfish, the left side of the larva giving rise to the oral, the right to the aboral side of the adult. The bilateral stage suggests a bilateral ancestor similar to Balanoglossus.

Studies of Recent Brachiopoda. — Seldom has a single year brought so many valuable additions to our knowledge of recent Brachiopoda as are represented by the five papers that form the subject of this review. In fact, the only period that at all compares with it is the year 1873, which saw the pioneer embryological work of Morse and Kovalevsky.

The first of these papers, by Dr. Conklin,[2] has to do with the same species '*Terebratulina septentrionalis*' that afforded Prof. Morse

[1] Masterman. A. T. The Early Development of Cribrella oculata (Forbes) with Remarks on Echinoderm Development. *Transactions Royal Society of Edinburgh*, vol. xl, pp. 373–418, Pls. I–V. 1902.

[2] Conklin, E. J. The Embryology of a Brachiopod, *Terebratulina septentrionalis*, Couthouy. From the Zoological Department of the University of Pennsylvania. *Proc. Amer. Philos. Soc.*, vol. xli, No. 168, pp. 41–76, pls. I–X, 1902.

material for the first investigation ever undertaken of the entire development of a brachiopod, and is a very careful reinvestigation of the early stages of this species by the aid of modern methods of preparation and microscopical technique. The early cleavage forms are found to present considerable variation, commonly in the production of very unequal divisions. These forms do not especially resemble those of the molluscs and annelids, but are more like those of the Bryozoa and Phoronis. Gastrulation is by invagination. The suggestion is offered that certain deep-staining granules seen at the free ends of the gastrula cells are associated with the cilia of the embryo. The archenteron at first possesses one constriction instead of two as in Cistella. The proper orientation of the embryo shows that it belongs to the hypogastric type, an important difference from the Chætognatha with which the Brachiopoda are sometimes supposed to present close relationship. The larva shows three regions,—cephalic, mantle, and peduncular, *which, however, are not true segments*. The mantle at first covers the peduncular region and is subsequently folded up over the cephalic portion. Dr. Conklin compares the embryo of Terebratulina with the trochophore and with the embryos of Phoronis and the Bryozoa, and concludes that the two latter groups and the Brachiopoda should go together in a single phylum, and that their relations with the Chætopoda and Chætognatha are not especially close.

"Observations on living Brachiopoda" by the veteran student of this class, Prof. E. S. Morse,[1] is a timely contribution to a much neglected subject. Occasional references to the habits of brachiopods may be found in various works, as those of Davidson, Œhlert, Woodward, etc., but Prof. Morse's paper contains by far the most extensive and valuable series of observations on the subject yet published. The title, however, does not convey an adequate idea of the extent of the work, for the author has given a large amount of anatomical detail, especially in regard to the mesenteries and perivisceral bands, sense organs, "hearts of Hancock," accessory hearts, etc., which is not confined to observations on the living object. The species chiefly considered are: *Glottidia pyramidata*, *Lingula lepidula*, and *L. anatina*, though in addition observations have also been made upon *Discinisca lamellosa*, and *D. stella*, *Terebratulina septentrionalis*, *Terebratalia coreanica*, *T. minor*, *Laqueus rubellus*, *Hemithyris psittacea*, *H. albida*, and *Dallina grayi*. The tenacity of life in brachiopods, especially

[1] Morse, E. S. Observations on living Brachiopoda. *Mem. Boston. Soc. Nat. Hist.*, vol. 5, No. 8, pp. 313–386, pls. 39–61, July, 1902.

in the Inarticulata, has often been a subject of remark. Prof. Morse succeeded in transporting live specimens of Lingula from Japan to this country. "One cannot help," he says, "associating this remarkable vitality of these genera with their persistence through geological horizons from the Cambrian to the present day almost unchanged in character." The freedom and extent of movement of the valves of Lingula, in locomotion and in burrowing, are quite at variance with Hancock's notion of the operation of the muscles, and much more in accord with what one would be led to expect from the general conformation of the valves. The action of the setæ of the anterior mantle margins of Lingula, in forming tubes for the passage of incurrent and excurrent water, is pointed out for the first time, though perhaps slightly anticipated by an observation by Yatsu. Another fact of much interest is the relation between the length of the setæ and the mobility of the valves upon the pedicle. When there is great mobility the setæ are long, and vice versa. Attention is called to the manner in which the ridges (striæ) of the shell of Terebratulina coincide with the setæ, though it is doubtful if there was any such connection as Morse suggests between the setæ and spines of such fossil brachiopods as Productus. The movements of the brachia are described as most graceful and varied. The two parts of the brachia are always moved simultaneously and symmetrically. The "heart of Hancock" is shown to exhibit none of the properties of a propellant organ, and is probably connected in some way with reproduction. This paper is profusely illustrated by outline drawings and one plate of colored drawings, which will be a revelation to those students who have never had the opportunity of viewing living brachiopods.

The three papers by Mr. Naohidé Yatsu deal with Japanese Lingulas. The development of *Lingula anatina*[1] is a contribution of the highest importance to our knowledge of brachiopod embryology. The earliest stages of development of this type are here detailed for the first time. Even the discharge of the sexual elements is noted. Females with ripe eggs will not discharge them if isolated from the males, so that probably the discharge of the sperm acts as a stimulus to the female to discharge her eggs. The breeding season lasts about one and one half months in Japan — from the middle of July to the end of August. The gastrula is formed by invagination.

[1] Yatsu, Naohidé. On the Development of *Lingula anatina*. *Journal College of Science*, Imperial University of Tokyo, Japan, vol. xvii, art. 4, pp. 1–112, pls. I–VIII, 1902.

The whole development of Lingula is preëminently direct, the mantle lobes growing over the cephalic region *ab initio*. There is consequently no inversion of the mantle lobes as in Cistella, Thecidium, etc. The embryo is also two lobed instead of three, as in the latter genera, the caudal lobe being absent in Lingula. "The shell is formed at first as a circular lamella folded double along one of its diameters, and is secondarily divided into two valves along the posterior edge." This is in marked contrast with the method of shell origin that obtains among the Articulata. In conclusion, attention is called to the resemblance between the mode of cleavage in Lingula up to the 32-celled stage and that of some species of Phylactolæmata. This is in harmony with the observations of Dr. Conklin above referred to, as is also the fact that in Lingula there is no true segmentation of the embryo.

Mr. Yatsu's paper on the Histology of Lingula[1] gives a detailed account of the several kinds of bodies found in the cœlomic fluid, namely, the blood corpuscles, leucocytes, and spindle bodies. An extended account is given of the latter — their form, occurrence, development, and significance. They are shown to be metamorphosed blood corpuscles, "*a cell whose nucleus has degenerated and whose cytoplasm has turned into a fibrous structure.*" Their function is excretory.

A third paper by the same author[2] deals with the habits of Lingula, and is extremely interesting. These forms live in mud flats which are exposed at low water, and though ordinarily no trace of them can be seen, their presence is sometimes detected by three small holes in the mud. These holes must be evidently produced by the setal tubes mentioned by Morse. The cirri of the brachia, though not the brachia themselves, can be protruded from the front of the shell. The life of Lingula may be as long as five years. Yatsu mentions the extreme tenacity of life in this genus. In one instance an influx of sediment that proved fatal to all the lamellibranchs of the locality had no effect upon the Lingulas. The plates which accompany these three papers by Mr. Yatsu certainly testify to his own and the lithographer's skill. They are models of clearness and beauty. E. R. C.

[1] Yatsu, Naohidé. Notes on the Histology of *Lingula anatina* Bruguiére. *Journal College of Science*, Imperial University of Tokyo, Japan, vol. xvii, art. 5, pp. 1–29, pls. I and II, 1902.

[2] Yatsu, Naohidé. On the Habits of Japanese *Lingula*. *Annotationes Zoologicæ Japanensis*, vol. iv, pl. 2, pp. 61–67, 1902.

Salmon and Trout.[1]— This is one of the most desirable of recent publications on angling. The three sections of which it is composed are unequal in quantity and to some extent in quality yet they effectually cover their field. The first section, of 149 pages, by Dean Sage, on the Atlantic Salmon, is a most excellent piece of work, however regarded. The dearest interests of the angler, habits, localities, tackle, capture. and the like, are admirably and thoroughly treated. Discussing but a single species, future changes of names and position can have little effect on this essay. Literary merit, accuracy, and inclusiveness combine to establish it as one of the most permanent contributions on the subject.

The second section, of about 40 pages, on "The Pacific Salmons," by Messrs. Townsend and Smith, is filled with information about species not as well known as *Salmo salar* and which apparently do not lend themselves as readily to the purposes of the sportsman.

The third section occupies more than 200 pages and, treating of "The Trouts of America," it deals with a considerable number of species. The author, Wm. C. Harris, is one of the first of living authorities on his topics and, so far as the matters of most importance to anglers are concerned, there is probably no one more competent. A veteran and an enthusiast he has the experiences of many years from which to draw material that is always full of life and entertainment. On whatever most directly pertains to angling and tackle or its manufacture his work has its greatest value. The technical science, in which he appears to take some pride, introduces elements that make for less of permanence. For the classification and nomenclature, and in great part knowledge of distribution, are only approximations, unsatisfactory and more or less discredited by the authorities, liable to be modified or superseded in the near future.

Opportunities for improvement on revision are not lacking. The following from page 194 will serve as an instance: "In 1486, six years before the discovery of America, Wynken De Worde, among the first of English printers, published that famous work, 'The Booke of St. Albans' on 'the dyssporte of fysshyng' by Dame Juliana Berners or Barnes, the Prioress of Sopwell in England; it was the first book on fish and fishing printed in the English language." This would make it appear that the Book of St. Albans and the Treatise of Fishing were identical; but in fact the "Treatyse of Fysshynge wyth

[1] Dean Sage, Townsend, C. H., Smith, H. M. and Harris, William C. New York: Macmillan, 1902. 8vo. pp. 417, illustrated.

an Angle," the first book on the subject of fishing printed in England, was published by Wynkyn De Worde in 1496, and the first edition of the Book of St. Albans, that of 1486, did not contain it. The cornea of the eye of fishes is said to be flat on page 307, the teeth on the head of the vomer of chars are badly treated on pages 274 and 288, the explanation of color on page 304 is not well done, and various items have been overlooked in proofreading.

The book is beautifully illustrated and printed; it contains a large proportion of all that is known of American Salmon and Trout and concerning their capture.

Boulenger on the Relationship of the Flounders. — In the *Annals and Magazine of Natural History* (Vol. X, pp. 295–304) Dr. Boulenger has a very suggestive discussion of the origin of the group of flounders or flatfishes.

He rejects entirely the idea that these fishes are related to the codfishes, with which group they agree in the absence of fin spines and in little else.

They are obviously more nearly related to the ordinary spinous-rayed fishes, showing a general similarity in the structure of skeleton, especially the shoulder girdle, the pelvis, and the tail. The increased number of ventral rays and other characters show real affinity with Zeus. Dr. Boulenger regards the John Dory, *Zeus faber*, as the nearest living ally of the flounders. In the Eocene rocks is found a genus, Amphistium, the type of a family Amphistiidæ, regarded by Boulenger as clearly intermediate between Zeus and the rhomboid flounders, which are the earliest known representatives of that group. The three families, Zeidæ, Amphistiidæ, and Pleuronectidæ, are joined together by Boulenger to form a new division of spiny-rayed fishes, which he calls Zeorhombi. The Amphistiidæ differ from the flounders almost solely in the symmetrical head and eyes, and have essentially the structure of the flounder larva, so far as the skeleton is concerned.

Incidentally Dr. Boulenger discusses the suggestion of the present writer that the notable fact of the smaller number of vertebræ in tropical fishes is due to the specialization of natural selection, a process less rapid in the cold regions, the fresh waters and the open seas. Dr. Boulenger claims that the form with twenty-four vertebræ, characteristic of the tropics, are at the same time the more primitive, and that the prevalence of this number of vertebræ in so many different groups simply indicates their common descent from

some Cretaceous or Eocene group of spinous fishes with like numbers of vertebræ.

This view is probably correct. Certainly paleontology and taxonomy agree in regarding the tropical flounders, percoids, scorpænoids, and blennies, with few vertebræ, as on the whole more nearly primitive than the cold-water or fresh-water forms which have many vertebræ. At the same time, these tropical forms are the most highly organized, the individual parts of the skeleton being most highly developed.

We may perhaps regard the tropical forms as having better maintained their primitive character of a highly developed skeleton, while the arctic and fluviatile forms have become degraded, their parts less developed and increased in number through repetition, this being due to less severity of selection and perhaps the demand for flexibility rather than strength of body.

In any case, the progressive increase in numbers of vertebræ in various groups, as we leave the coral-reef region, is an unquestionable fact, and must have some cause potent among all fishes. The only cause yet suggested is that of the demands of natural selection in the tropics, with its cessation or reversal elsewhere. But in many groups it is certain that the forms with many vertebræ were not as nearly primitive as the others. D. S. J.

Boulenger on Selenichthyes. — In the *Annals and Magazine of Natural History* (Vol. X, pp. 147–153) Dr. G. A. Boulenger takes up the relationship of the large pelagic fish known as the opah or moonfish (*Lampris luna*).

This species has been usually placed, without evident reason, with the mackerel-like forms. It has, however, the very archaic number (15 to 17) of rays in the ventral fins, and these fins are subabdominal in position, although placed well forward. It has the clavicle very large, and behind it, attached to the hypercoracoid, is a very large, flat plate, called the infraclavicle, apparently corresponding in Boulenger's opinion to the interclavicle of sticklebacks. The small hypercoracoid above this plate is on the level of the hypocoracoid, and out of its normal position.

Dr. Boulenger makes this fish the type of a new division called Selenichthyes, moon-fishes. This he regards as nearest allied to the Hemibranchii; and for the two groups, with the Lophobranchii and Hypostomides, he proposes a new suborder, Catosteomi, characterized by the development of interclavicles.

As to this, it may be urged that it is not clear that any close affinity exists between Lampris and the others (sticklebacks, pipefishes, sea horses and sea dragons), referred to Catosteomi. The retention of various archaic characters constitutes the sole bond of union excepting the presence of interclavicles. Furthermore, according to Mr. E. C. Starks, interclavicles are wanting in Centriscidæ and Macrorhamphosidæ, both families of undoubted hemibranchs. He regards the interclavicle as a mere backward or downward extension of the hypercoracoid, not as a separate bone. There is no evidence that the infraclavicle of Lampris is homologous with this structure: It is very different in form and place from the interclavicle of the stickleback, and it may be the ordinary hypercoracoid simply enlarged.

There is no doubt of the validity of the group Selenichthyes, whatever its relation to the other Catosteomi. The present writer had defined it as a distinct suborder, under another name, in a paper now in press.

In the same paper Dr. Boulenger defines the families of Catosteomi, adding a new one, Protoryngnathidæ, based on fossil sticklebacks, with tubiform snout, free ribs, and the first vertebra enlarged.

D. S. J.

Meek on Fishes of Mexico. — One of the very best of recent faunal papers is Dr. Seth E. Meek's "Contribution to the Ichthyology of Mexico."[1] It is based on the largest collection of Mexican fishes yet made. This was obtained in the spring of 1901 by Dr. Meek and Mr. Frank E. Lutz in the lakes and streams of the central table-land of Mexico. Ninety-seven species were obtained. Many of these had been secured in the previous expeditions of A. J. Woolman and of Jordan and Snyder to the same region, but an unexpectedly large number of new ones were also secured. New genera are Zoogoneticus, based on *Platypœcilus quitzeoensis*; Chapalichthys, on *Characodon encaustus*; Skiffia, allied to *Characodon*, based on *Skiffia lermæ*; and Melaniris, based on *Melaniris balsanus*, allied to Chirostoma; Xenendum proves to be inseparable from Goodea. The new species are *Rhamdia oaxacæ*, from Oaxaca; *Catostomus sonorensis*, from Chihuahua; *Algansea rubescens*, from Ocatlan, Lake Chapala; *Gila minacæ*, from Chihuahua; *Aztecula mexicana* from Queretaro; *Notropis robustus*, from Chihuahua; *Notropis santarosaliæ* from Chihuahua; *Evarra tlahuacensis* from Lake Chalco, Mexico; *Fundulus oaxacæ*, from Oaxaca; *Zoogoneticus diazi*, from Lake Pátz-

[1] *Publications Field Columb. Mus.*, Zoöl. Ser., vol. iii, No. 6.

cuaro; *Zoogoneticus miniatus*, from Lake Chalco; *Skiffia lermæ*, from Lake Patzcuaro and Rio Lerma; *Skiffia variegata*, from Lake Zirahuen; *Heterandria lutzi*, from Oaxaca; *Xiphophorus jalapæ*, from Jalapa; *Chirostoma attenuatum*, from Lake Patzcuaro; *Chirostoma labarcæ*, from Rio Lerma; *Chirostoma patzcuaro*, from Lake Patzcuaro; *Chirostoma zirahuen*, from Lake Zirahuen; *Melaniris balsanus*, from Rio Balsas; *Lepomis occidentalis*, from Chihuahua; *Cichlasoma eigenmanni*, from Pueblo; *Gobius parvus*, from Vera Cruz; and *Gobius claytoni*, from Vera Cruz. These two species are apparently referable to Ctenogobius. *Chirostoma lucius* is identified with *C. crystallinum*, not with *C. lermæ*.

The most remarkable feature of this fauna is the extraordinary number of closely related species of Atherinidæ, alike in size, color, and appearance, and living in the same waters.

Jordan and Snyder found, in 1895, six such species, each about a foot long, in Lake Chapala. To this list Dr. Meek makes further additions. All these fishes are excellent as food and all locally known alike as Pescado Blanco de Chapala. Dr. Meek unites the small genera Eslopsarum (with large scales) and Lethostole (translucent, with crenate scales) to Chirostoma. The genus as thus constituted is known only from the table-lands of Mexico.

The species are distributed as follows;

Lake Chalco (City of Mexico): *Chirostoma jordani*, *C. humboldtianum*.

Aguas Calientes, *E. arge*.

Lake Chapala, with L. Zirahuen and Rio Lerma: *C. bartoni*, *C. labarcæ*, *C. zirahuen*, *C. chapalæ*, *C. grandocule*, *C. promelas*, *C. lucius*, *C. sphyræna*, *C. lermæ*, *C. ocotlane*, and *C. estor* (= *C. album*).

Lake Patzcuaro: *C. attenuatum*, *C. patzcuaro*, *C. humboldtianum*, *C. grandocule*, and *C. estor*.

Dr. Meek has several interesting suggestions concerning geographical distribution. These isolated rivers and lakes have fish faunas to be compared with those of rivers on different islands, separated by the sea. But the barriers of ocean are often more easily passed than those of the Sierra Madre. The new species are all well figured. D. S. J.

Fishes of Formosa. — In the proceedings of the United States National Museum, Vol. XXV, pp. 315–368, Jordan and Evermann give an account of the Formosan fishes contained in museums of Japan. Two collections were studied, — the one made by Mr. T.

Tada of Osaka for the Imperial University, the other by Japanese officers for the imperial school of fisheries; 186 species in all were examined. Seventeen new species are described and figured. With them are two new genera, — Zacco (Cyprinidæ), based on *Opsariichthys platypus* and Evenchelys (Murænidæ), based on *Gymnothorax macrurus*. The summary shows that the fauna of Formosa is essentially similar to that of the region about Hongkong, and that it bears much closer relation to that of India than to that of southern Japan, while the fish fauna to the north of Tokyo contains very little in common with that of Formosa.

One of the new species deserves additional comment. The systematic position of the family of sand launces, or Ammodytidæ, has been long in question. Early writers placed it among the jugular fishes as an ally of the cusks and pearlfishes. It has no ventral fins at all, but as there are no spines in any of the fins, it was presumed that the ventrals, if present, would be few rayed and jugular in position.

More recently the resemblance in general structure of the sand launces to the silversides and other groups called Percesoces, transitional forms between soft-rayed and the more recent spiny-rayed fishes, have led to a reconsideration of this opinion. The Percesoces have abdominal ventrals and the spines little developed. Two arguments in favor of this view have seemed to have value. In 1811 Pallas described an *Ammodytes septipinnis* from the Aleutian Islands. This species, not since recognized, is said to be an Ammodytes, or sand launce, with the ventral fins eight-rayed and abdominal. For this species Dr. Gill has suggested the generic name of Rhynchias.

In the Oligocene rocks of Puy-de-Dôme Dr. Gervais has discovered a fossil fish, now called *Cobitopsis acuta*, which resembles a sand launce in most respects, and is referred to the Ammodytidæ by Boulenger. In this species the ventrals are six rayed, and abdominal. The dorsal fin, unlike that of Ammodytes, is rather shorter than the anal and opposite to it. There are no fin spines. The long dorsal, without fin spines, the numerous vertebræ and abdominal ventrals with six or eight rays, appear also in the extinct family of Crossognathidæ of the Cretaceous. This family is certainly allied to the Percesoces. This evidence seemed conclusive, and the sequence of families, Crossognathidæ, Cobitopsidæ, Ammodytidæ, and Atherinidæ, seemed a natural one.

The tropical Ammodytidæ, having normal scales and fewer vertebræ, have been referred to the genus Bleekeria. In the collection

from Formosa is a new species, *Bleekeria mitsukurii*, which differs from the other species of Bleekeria in the presence of ventral fins. These are very small, jugular in position, and composed of a slender spine and three rays. The scales in this species are very small, about 115 in a longitudinal series, this count being, by a slip of the copyist, omitted in the published description. This species shows conclusively that the Ammodytidæ are not related to the Percesoces, are not derived from Cobitopsis or Crossognathus, and that their real place is with the ophidioid fishes and Fierasfer. The Formosan species is the type of a distinct genus, characterized by the presence of ventral fins. For this, the name Embolichthys Jordan and Evermann (*ἔμβολος*, a hint) has been elsewhere proposed. D. S. J.

Fishes of Japan. — The series of monographic reviews of the fishes of Japanese waters is continued by Jordan and Fowler, and Jordan and Snyder, in the *Proceedings* of the United States National Museum. (Vol. XXV). There is included: 1. A "Review of the Salmonoid Fishes," the Salmonidæ, (10 species); the Argentinidæ, (4 species), and the Salangidæ, (2 species). Four salmon, (*Oncorhynchus masou*, *O. keta*, *O. kisutch*, and *O. nerka*) are found in Japan, one of these, *O. masou*, not yet known from any other region. One salmon trout, *Salmo perryi*, is found in all streams of middle and northern Japan. A large pikelike trout, *Hucho blackistoni*, common in northern Japan, finds its only analogue in the huchen (*Hucho hucho*) on the Danube. There are three charrs in Japan, — one common, *Salvelinus pluvius*; the other two, *S. kundsha* and *S. malma*, confined to the northern islands. The ayu, *Plecoglossus altivelis*, is found in all rivers. It is one of the finest food fishes in the world, — a sort of dwarf salmon with peculiar dentition.

Of the smelt, *Osmerus dentex*, *Mesopus olidus*, and *Mesopus japonicus* are described, besides a new species *Argentina kagoshimæ*. Besides the diminutive and fragile Japanese ice-fish, *Salanx microdon*, a second species, *Salanx ariakensis* is described from manuscripts of Dr. Kishinouye.

The part of this paper of popular interest in Japan is condensed in an article, "The Salmon and Trout of Japan," in the "*Annotationes zoologicæ Japonenses*," published by the Imperial University of Tokyo.

2. A "Review of the Labroid Fishes and Related Forms" includes 45 species: of Pomacentridæ, 11; Labridæ, 31; and Scaridæ (3). The new species are *Stethojulis psacas*, *S. terina*, *S. trossula*, and

Halichœres tremebundus. All these and several other species are figured.

3. The Chætodontidæ and related families are next discussed. Twenty-seven species being represented in Japanese waters. The new species are *Cyttopsis itea*, *Chætodon dædalma*, *Holacanthus ronin*, and *Coradion desmotes*. The first-named species, *itea*, should not have been placed in Cyttopsis, as it has the ventral rays I, 9, and the breast broad and flat, with feeble plates. It is made elsewhere the type of a new genus, Zen Jordan, its name becoming *Zen itea*.

4. A discussion of the Blennies. This interesting group of fishes is well represented in all the rock pools of the Japanese islands, — the elongate species, with many vertebræ in the north; the short-bodied, tropical forms to the southward. Forty-four species are described, representing twenty-four genera. Of these genera, the following — Zacalles, Azuma, Zoarchias, and Abryois — are here characterized for the first time. Twenty species are described as new, most of these represented by great numbers of specimens, the outlying rocks of Hakodate and Misaki proving especially rich in fishes of this type. The plates are the work of Mrs. E. C. Starks and of Capt. Charles B. Hudson, and deserve especial commendation for their accuracy and neatness.

5. The Balistidæ and Ostraciidæ. Twenty-four species are described, two of them being new. These are *Brachaluteres ulvarum* and *Rudarius ercodes*. Rudarius is a new genus allied to Monacanthus. D. S. J.

Notes on Recent Fish Literature.— In the *Bulletin* of the *Museum of Comparative Zoology* (Vol. XXXIX, No. 3) Dr. C. R. Eastman gives a valuable series of notes on extinct cestraciont and acanthodian sharks.

The extraordinary species of Edestus and other extinct forms are thought by Eastman to be consolidated whorls of teeth of cestraciont forms. These extraordinary structures have formed a standing puzzle, it being uncertain whether their nature was that of teeth, of fin spines, or, as conjectured by Karpinsky, of a coiled horn at the tip of the snout. The critical study of these structures by Dr. Eastman leaves little doubt that these structures in *Edestus*, *Campyloprion* and *Helicoprion* are really teeth.

Dr. Eastman describes a number of fin spines, apparently cestraciont, referable to the genus Ctenacanthus. Two new species of Acanthodes, *A. marshi* and *A. beecheri* are described from the rich

beds of Mazon Creek, Illinois. A series of excellent plates illustrate the species under discussion.

In the *Bulletin of the United States Fish Commission* for 1901, pp. 131–159, Dr. B. W. Evermann and E. L. Goldsborough describe the fresh water fishes collected by E. W. Nelson and E. A. Goldman in Yucatan and neighboring regions, besides a few small collections from other points of Mexico. The new species are as follows: *Conorhynchos nelsoni* from Rio Usumacinta, *Notropis santamariæ* from Chihuahua (Lake Santa Maria), *Notropis lermæ* from Lake Lerma, *Cichlasoma teapæ* from Teapa in Tobasco, and *Batrachoides goldmani* from Rio Usumacinta. The fresh water drum *Aplodinotus grunniens* was found in Rio Usumacinta. It was never before noticed south of the Rio Grande.

In the *Proceedings of the United States National Museum* (Vol. XXV, pp. 79–81), Jordan and Snyder describe two small sharks allied to the Dog-fish from deep waters of the coast of Japan. These species are black in color, and one of them *Etmopterus lucifer*, has a glandular substance in the skin of the side of the belly, which is said to be luminous in life. The other sharklet, *Deania eglantina*, differs from *Etmopterus* in its bristly surface. It is made the type of a distinct genus named for Dr. Bashford Dean. Jordan and Fowler give also a review of the Stone-wall-Perches, *Oplegnathidæ* of Japan. Two species are described.

In the Report of the United States Commissioner of Fish and Fisheries, for 1901, Evermann and Goldsborough catalogue the fishes and mollusks of Lake Chautauqua, 31 fishes are enumerated, the Chautauqua Muskallunge, Esox *ohioensis*, being much the most importance. — Evermann and Kendall publish notes on the fishes of Lake Ontario, 73 species, on the fishes of Lake Champlain, 54 species, and on the fishes of St. Lawrence River, 71 species, giving the known localities and the common names of each species. — In the same report Mr. William C. Kendall reviews the silver-sides or brit of the East Coast of the United States, belonging to the genus *Menidia*. These little fishes are excellent as food, and invaluable as food of the larger species. Mr. Kendall gives figures of most of the recognized species, *peninsulæ*, *audens*, *baryllina*, and *menidia*, and describes two new varieties, *Menidia peninsulæ atrimentis* from Titusville, Florida, and *Menidia beryllina cerca* from Waquoit Bay and other localities.

In the *Journal of the Imperial Fisheries Bureau of Japan* Dr. Kamakichi Kishinouye presents a monographic review of the Japanese Tai or species of the genus Pagrus. The *Tai* is perhaps the most valuable fish of Japan, always common, always excellent. The fish god, Ebisu, is always represented in Japanese drawings as bearing a red Tai, "Akadai," *Pagrus major* under his arm. Dr. Kishinouye rejects the supposed species *Pagrus ruber* and describes three valid species, *Pagrus major*, *Pagrus cardinalis* and *Pagrus tumifrons*. Later Dr. Kishinouye (in lit) has announced the discovery that the last named species is a Deutex. *Deutex tumifrons* has been described by Blecher as *Deutex hypselosoma*. The descriptions are accompanied by excellent colored plates, the work of Mr. J. Urata.

In the *Denkschriften* of the Academy of Vienna Dr. Franz Steindachner gives an account of the fishes and reptiles collected by the naturalist, Princess Therese of Bavaria, on her trip from Martinique to Guayaquil around the coast of South America. Eight new species are described and most of them figured. These are *Prionodes* or *Serranus huascarii* from Payta, *Pomadasis schyri* from Guayaquil, *Pontinus dubins* from Payta, *Mugil charlottæ* from Guayaquil, *Pimelodella yunceusis* from Pacosmayo, *Pygidium quechuorum* from Arequipa, *Loricaria aurea* from Bodega, and *Leporinus muyacorum* from Santander in Colombia. Steindachner adopts the name *Doydixodon lævifrons*, referring other nominal species to its synonymy.

Dr. George A. Boulenger, in the *Proceedings of the Geological Society of London* discusses the young of the ten known species of Polypterus, with figures of the seven species found in the Congo, showing the peculiar external gill which looks not unlike an "archipterygium." In the young of *Polypterus lapradii* this gill is half as long as the body, extending backward parallel with the pectoral.

In the *Actes Soc. Scient. du Chili*, Dr. Federico T. Delfin, writes of the voracity of the Chilian hag-fish (*Eptatretus dombey*). He finds that one example having free opportunity to destroy fishes devoured in seven hours 18 times its own weight of their flesh. This amount was not assimilated but passed through the straight alimentary canal of the parasite, most of it little changed. The species fed to the hag-fish is in another paper described as a new genus of Sciænidæ under the name of *Cilas montti*.

In a "Report on the Collections made by the Southern Cross," Dr. Boulenger records species of fishes taken in Antarctic regions. In this is given a useful synopsis of genera and species of Nototheniidæ, a family of fishes especially characteristic of that region.

Pleuragramma antarcticum a leptoscopoid fish, was taken at Lat. 78°35′ south, the southernmost fish yet known.

In the *Popular Science Monthly* Mr. Cloudsley Rutter gives the results of elaborate studies in the Natural History of the salmon of the Sacramento River. D. S. J.

Hay on Fossil Vertebrates. — Under the head of Bibliography and Catalogue of the Fossil Vertebrate of North America, in the *Bulletin of the United States Geological Survey* (*No. 179*), Dr. Oliver Perry Hay has published a work of immense practical value to the student of Zoölogy. It is a conscientious and laborious compilation of the kind that wins gratitude rather than fame, although amply deserving both.

The synonymy of each name of group, genus and species is given, with a reference to the original type of each genus and the type locality of each species. The rules of nomenclature of the American Ornithologists' Union are adopted and consistently applied, and the general sequence and classification is that approved by American authors. Of fossil fishes, about 1000 species are enumerated, nearly one third as many as now inhabit the region (North America) under discussion.

The series begins with the Ichthyotomus sharks, Ichthyotomi being regarded as a "Superorder," including the Pleuropterygia and the Acanthodii as well as the Pleuracanthine sharks. As against the Ichthyotomi the other sharks are set off as a second superorder called Euselachii. The generic name, Acanthoëssus on account of priority, is substituted for the familiar name Acanthodes. It is claimed by Bashford Dean that the species on which Acanthoëssus is based is not certainly identified. Unless this plea is maintained, Acanthoëssus must stand.

A new family, Tamiobatidæ, is established for Eastman's genus, Tamiobatis, from palæozoic rocks in Kentucky. The name Pisces is defined so as to include all fishes except the sharks; Gill's name, Aspidoganoidei is used instead of the preoccupied name of Ostracodermi and Cope's later substitute of Ostracophori. The name "Aspidoganoid" seems unfortunate, as these fantastic creatures have little in common with ganoids. For a group containing the Arthrodira

and Dipnoans, Dr. Hay proposes a new subclass, Azygostei, the Crossopterygians, Ganoids and ordinary fishes forming a third subclass, Teleostomi. Apparently the relative position of Dipnoans, Crossopterygians, Arthrodira and Aspidoganoids is not yet clear enough to render this arrangement inevitable. The Arthrodira may be allied to the Aspidoganoids; the Aspidoganoids may be modified sharks, or even modified lampreys. The Crossopterygians may be ancestors of Dipnoans on the one hand and of Ganoids and bony fishes on the other, and there are numerous other elements of uncertainty. Under the head of the superorder Placodermi, Dr. Hay removes the Antiarcha (Asterolepis etc.) from the Aspidoganoids, and places them alongside the Arthrodira, which are regarded as a second order of Placoderms. The other superorder of Azygostei is that of Dipnoi. Pterichthyodes is necessarily substituted for the familiar but preoccupied name, Pterichthys; Phlyctænaspis is needlessly substituted for Phlyctænius, on account of the earlier name Phlyctænium. Naturalists must sooner or later come to the rule that a name is constituted by its spelling, not by its etymology. Words spelled differently are different words. Puer is a definably different creature from *puella*, whatever the likeness.

Under the subclass Teleostomi, we have two superorders, Crossopterygia and Actinopteri. The name Ganoid disappears, the different types forming three orders, Chondrostei, Pycnodonti and Holostei, at the base of the series of Actinopteri. The name Megalichthys replaces the later Rhizodus, and Parabatrachus is applied to the genus formerly wrongly called Megalichthys. Palæoniscum is restored as the original spelling of Palæoniscus, and Lepisosteus as the original, though unclassic orthography of Lepidosteus. Redfieldius is used for the genus, wrongly called Catopterus, by J. H. Redfield.

Ginglymodi is restored as the name of the suborder of Gars, and Halecomorphi for the relatives of Amia. The name Eugnathus, preoccupied, is replaced by Isopholis; Erisichthe and Pelecopterus are united with Protosphyræna and placed with the Pachycormidæ among the Halecomorphi.

The Nematognathi are separated from the Plectospondyli and placed before the Isospondyli, where apparently they do not belong. The Suckers are reduced to a subfamily of Cyprinidæ. A new order, Phthinobranchii, is proposed to include the Hemibranchii and the Lophobranchii, two groups not fundamentally distinct. The Catosteomi of Boulenger corresponds to this group, except for the inclusion of Lampris, a genus of peculiar and primitive structure, but surely

not related to the stickle-backs. Another new order, Mesichthyes, is proposed to include the Haplomi, Synentognathi and Percesoces. But while these groups are closely related, they differ almost as much among themselves as the Haplomi differ from some Isospondyli or the Percesoces from some Percomorphi. It is not clear that the Phthinobranchii really differ much from the Percesoces, especially since Mr. Starks has shown that the interclavicle, or infraclavicle, supposed to distinguish the former, is merely an expansion of the *hypocoracoid*, and that it is wanting in Macrorhamphosus, Centriscus and Aeoliscus among the Hemibranchs. The arrangement of these transitional fishes in distinct orders, or suborders, offers very great difficulties, because the groups, adopted though natural, are not set off by strong characters.

The Chætodonts, Labroids and Pomacentrids are placed first among Percomorphous fishes— for no evident reason, as the Berycidæ are more primitive in structure and earlier in time. Surely Chætodipterus does not belong to Chætodontidæ, nor Priscacara to the Pomacentridæ, nor Platax to the Carangidæ.

Erismatopterus, Amphiplaga, Asineops and Trichophanes are placed in the Aphredoderidæ. Near the Aphredoderidæ, would be safer. The suborder Pareioplitæ replaces the preoccupied name Loricati for the mailed-cheek fishes.

Dr. Hay has earned the lasting thanks of his brother ichthyologists for the pains he has taken in this work, and the portions treating of the groups higher than fishes will doubtless be found as carefully done and as helpful.

DAVID STARR JORDAN.

Notes. — Ikeda (*Journal of the College of Science*, Tokyo, Vol. XVII) has made an extended series of experiments to determine the mode of closure of the blastopore and the position of the embryonic body in amphibian eggs. He shows that the results obtained by puncturing eggs and by other similar methods can never be depended upon to reveal the normal course of development, for widely differing results are obtained depending upon the position of the puncture. He believes that the embryonic body in Amphibia may be formed at any position on the egg surface, and that many authors have overlooked or underestimated the varying rate at which different parts of the blastoporic lip enclose the yolk-mass, a rate which determines the final closing point of the blastopore and consequently the position of the embryo.

Kishinouye has recently published (*Jour. Col. Sci. Tokyo*, Vol. XVII) descriptions of five new species of Japanese Scyphomedusæ. All represent new genera and one a new family of the Stauromedusæ, Stenoscyphidæ.

The octopod genus Amphitretus has thus far been known only through a single specimen collected by the "Challenger" and described by Hoyle. A second specimen taken by the collector of the Missaki Marine Laboratory in the deep water of Sagarni Sea, Japan, in 1897, is now described by Ijima and Ikeda (*Annotationes Zoologicæ Japonenses*, Vol. IV). The animal, which was nearly half a foot long, was bell-shaped, semigelatinous and more or less transparent. The more important internal parts could be discerned through the outer gelatinous layer in which chromatophores were embedded. Unlike all other Cephalopods the mantle is fused with the siphon in the median plane so that there are two branchial openings into the branchial cavity. A colored figure of the appearance of this remarkable animal during life accompanies Ijima and Ikeda's description.

The osteology of the shoulder girdles of the hemibranchiate fishes is the subject of a paper by E. C. Starks in Vol. XXV of the *Proc. U. S. Nat. Mus.*

Brief accounts of the development and degeneration of the eyes in the blind fish, Amblyopsis, and of the structure of the degenerate eyes in the amphisbænian lizard, Rhineura, have been given by C. H. Eigenmann in the *Proc. Indiana Acad. Sci.* for 1901.

A summary of the questions concerning the propagation of the common eel forms the subject matter of an address by the President of the American Microscopical Society, C. H. Eigenmann. The address is published in the Transactions of the Society.

The increase of mesenteries in the madrepore corals has been studied by J. E. Duerden (*Ann. Mag. Nat. Hist.*, Ser. 7, Vol. X, August, 1902), who finds that in most polyps of the genus Madrepora only the six bilateral pairs of primary mesenteries are developed. In any colony a few large polyps may possess a greater number of mesenteries, in which case the new mesenteries are added as bilateral pairs at only the two axial extremities of the polyp, the enterocoels of the dorsal and ventral directives. The mesenterial increase is early associated with fission of the stomodæum and in the end probably with complete fission of the polyp in which half the mesenteries of each fission polyp are derived from the primary twelve of the original polyp and the other half are new formations.

The same author, (*Bull. Amer. Mus. Nat. Hist.*, Vol. XVI, pp. 323–332) calls attention to the great importance of boring algæ as a factor in the disintegration of corals. These grow most vigorously in quiet lagoons and thus contribute to the rapid decay of corals known to take place in such situations. They are, therefore, to be reckoned among the numerous elements concerned with the formation of coral islands.

The crustacean fauna of Nickajack Cave, Tennessee, has been investigated by W. P. Hay (*Proc. U. S. Nat. Mus.*, Vol. XXV, pp. 417–439). A new species of Cæcidotea, closely related to *C. nickajackensis* Packard, a new species of Gammarus, and two new subspecies of crayfishes are described.

Notes on the structure and development of a species of barnacle, *Dichelaspis mülleri*, found parasitic on the gills of crabs, have been published by R. E. Coker (*Bull. U. S. Fish Com. for 1901*, pp. 399–412).

BOTANY.

McIlvaine and Macadam's "American Fungi." [1] — A second edition of this book, which appeared first in 1900, has been brought out, and differs from the original edition in the addition of a supplement of twenty-five pages, including one full plate and several cuts. There is no equally full and fully illustrated book on the edible and poisonous fungi of this country, and though bulky and somewhat inconvenient for use, it is much lighter than the original issue and it ought to be in the hands of all who collect fungi for the table.

W. T.

Notes.— *Postelsia*, the new yearbook of the Minnesota Seaside Station, makes its appearance in a very attractive form, in the issue for 1901, recently distributed. This volume consists of seven chapters, or lectures, illustrated.

A new periodical, *Annales Mycologici*, under the editorship of H. Sydow and devoted to Fungi, is announced to appear at the opening of 1903, through the book house of R. Friedländer and Sohn, of Berlin.

[1] McIlvaine, Charles, and Macadam, Robert K., *One Thousand American Fungi*. Revised edition. Indianapolis, The Bowen-Merrill Company, 1902. Quarto, xxxvii + 729 pp. Numerous plates, some of them in color, and line cuts. $5.00.

Since October, 1901, an *Agricultural Bulletin of the Straits and Federated Malay States*, edited by H. N. Ridley, has been issued monthly from the Government Printing Office at Singapore.

The *Proceedings of the Indiana Academy of Science*, for 1901, contain a number of botanical papers, several of them referring to the flora of the state.

Rhodora for September contains the following articles: Jones, "The Pringle and Frost Herbaria"; Collins, F. S., "An Algologist's Vacation in Maine"; Collins, J. F., "Distinctive Features of *Iris Hookeri*"; Grout, "Notes on Vermont Mosses"; Leavitt, "Seed Dispersal of *Viola rotundifolia*"; Bacon, "*Anagallis arvensis* and *cærulea* in Vermont"; Fernald, "*Aster undulatus* × *Novi-Belgii*"; Webster, "A form of the Bitter Boletus"; Hoffmann, "Virulence of the Wild Parsnip," and reports on the Josselyn Society and the Vermont Botanical Club.

The *Botanical Gazette* for September contains the following articles: Copeland, "The Rise of the Transpiration Stream," (part); Chandler, "Revision of the Genus Nemophila"; Worsdell, "Evolution of the Vascular Tissue of Plants"; MacMillan, "Suggestions on the Classification of Seeds"; and Fairchild, "The Sensitive Plant as a Weed in the Tropics."

The *Bulletin of the Torrey Botanical Club* for September contains the following: Piper, "Notes on the Biennial and Perennial West American Species of Lappula"; White, "Some Mt. Desert Fungi"; Hill, "Notes on Migratory Plants"; Burt, "Some Hymenomycetous Fungi from South America"; and Cotton, "Three new plants from Washington."

Torreya for October contains the following articles: Hollick, "Fossil Ferns from the Laramie Group of Colorado"; Howe, "*Caloglossa leprieurii* in Mountain Streams"; Earle, "Key to the North American Species of Lactarius, II"; Cockerell, "Some New Mexico Plants"; Harper, R. M., "A visit to Okefinokee Swamp in Southern Georgia"; Rydberg, "Is the White Fruited Strawberry of Pennsylvania a Native Species?"; and Earle, "A Much Named Fungus."

The *Popular Science Monthly* for October contains two articles of considerable botanical interest; Toumey, "A Study in Plant Adaptation"; and Cook, "The American Origin of Agriculture."

Of the leaflets of *Proceedings of the Biological Society of Washington* issued under date of October 10, several refer to botany.

A *Flora Arctica*, in English, under the editorial care of C. H. Ostenfeld, is being issued from Det Nordiske Forlag, of Copenhagen. The first part, dealing with the Pteridophytes, Gymnosperms, and Monocotyledons, by Gelert and Ostenfeld, occupies 134 well illustrated pages.

Vol. XXXIV of the *Transactions and Proceedings of the New Zealand Institute*, issued in July last, has 166 pages devoted to botany, chiefly referring to the island. Perhaps the most generally interesting paper is one on the prothallus of Phylloglossum.

An important "Flora of Koh Chang," by Schmidt, with the assistance of a number of specialists, is being published in current numbers of the *Botanisk Tidsskrift.*

A further study of the revegetation of Krakatoa, by Penzig, is contained in the concluding number of Vol. XVIII of the *Annales du Jardin Botanique de Buitenzorg.*

A discussion of the southeastern United States as a center of geographical distribution of both animals and plants, is reprinted by C. C. Adams from the *Biological Bulletin*, Vol. III, No. 3.

Some of the Crassulaceæ of South Africa are being revised by Schönland and E. C. Baker in current issues of the *Journal of Botany.*

A voluminous study of the Myricaceæ, by Chevalier, occupies a large part of Vol. XXXII of the *Mémoires de la Société nationale* of Cherbourg.

Separates of a paper on the Carices of Japan, by Léveillé and Vaniot, have been separately printed from the *Bulletin de l'Académie internationale de géographie botanique.*

An extensive and well illustrated paper on the fern-worts of Kouy-Tcheou, by Christ, forms a large part of the *Bulletin de l'Académie internationale de géographie botanique* for August–September.

An important paper on the structure and development of the stem in the Pteridophyta and gymnosperms, by Dr. Jeffrey, is separately distributed from Vol. CXCV of the *Philosophical Transactions of the Royal Society of London.*

Fibro-vascular studies on the ferns, by Bertrand and Cornaille, are contained in the *Comptes Rendus de l'Académie des Sciences* of Paris,

for 1901 and 1902, and the *Bulletin de la Société botanique de France* and the *Procès-Verbaux de la Société d'histoire naturelle d'Autun*, for the present year.

A paper on the life history of *Vittaria lineata*, by Elizabeth G. Britton and Alexandrina Taylor, forms the concluding number of Vol. VIII of the *Memoirs of the Torrey Botanical Club.*

Descriptions of two new species of fossil algæ, of the genus Buthotrephis, from Indiana, are separately issued by David White from the *Proceedings of the United States National Museum.*

The *Journal of Mycology* for October, with portrait of J. C. Arthur as frontispiece, contains the following articles: Morgan, "Notes on North American Fungi"; Atkinson, "Preliminary Note on Two New Genera of Basidiomycetes"; Durand, "The Genus Angelina"; Atkinson, "Preliminary Notes on Some New Species of Fungi"; Kellerman, "Ohio Fungi" (fascicle v); Ricker, "Notes on Some West American Fungi"; Clinton, "North American Ustilagineæ"; Harshberger, "Notes on Fungi"; and Kellerman, "Notes from Mycological Literature, II."

The first part of the *Monographia Uredinearum*, by P. and H. Sydow, has been distributed from the Borntræger press of Leipzig, and is almost entirely occupied with the Puccinias of Compositæ, of which 298 are described, not a few of them new.

By a typographical error, a paper on Uredineæ, by Pennington, has been separately issued from the *Anales de la Sociedad Científica Argentina*, Vol. LIII, under a cover reading "Erudineas recolectadas en las islas del delta del Parana."

Van Bambeke considers the crystalloids of Autobasidiomycetes, in the *Bulletin de la classe des sciences, Académie Royale de Belgique*, No. 4, for 1902.

An illustration of the need of care in the determination of plants on which morphological studies are made, is given by Rehder in an open letter in the *Botanical Gazette* for September.

Volumes II and III of the *Archives de l'Institut botanique de l'Université de Liége* consist of five long papers on plant anatomy.

A study of the pith diaphragms of dicotyledons, by Mágócsy-Dietz, is found in Vol. VII of the *Mathematische und Naturwissenschaftliche Berichte aus Ungarn.*

Van Tieghem discusses the classificatory value of the embryo in Ochnaceæ in No. 3 of the current volume of the *Bulletin du Muséum d'histoire naturelle*, of Paris.

An article on "School Gardens in Cities," by Helen C. Putnam, containing the first general review of school gardening in this country, with a synopsis of what is done abroad, is contained in the *Rhode Island School Report* for 1902.

A short account, with illustration, of the public gardens at Shanghai, is contained in the *Gardener's Chronicle* of September 27.

An instructive and handsomely illustrated report of the Secretary of Agriculture on the forests, rivers, and mountains of the southern Appalachian region, with the President's message transmitting it to Congress, has recently been issued from the Government Press.

An attractive little pamphlet on *Vigna sinensis*, the cowpea of the South, has been issued by the experimental farm of the North Carolina Horticultural Society, at Southern Pines.

The Agave cultivated largely in the Mexican state of Jalisco for the manufacture of the distilled beverage known as Tequila, is described by Weber, under the name *A. tequilana*, in the *Bulletin du Muséum d'histoire naturelle*, of Paris, No. 4 of the current volume.

An account of the Peen-to peach, and a series of varieties that have been selected from it in Florida, by Professor Hume, constitutes *Bulletin No. 62* of the Florida Agricultural Experiment Station.

Dr. Fairchild publishes an account of Spanish almonds and their introduction into this country, as *Bulletin 26* of the Bureau of Plant Industry, of the Department of Agriculture.

A well illustrated article on the cultivation of coffee has been published by Sajo in recent numbers of *Prometheus*.

An account of the China aster and its diseases, by R. E. Smith, constitutes *Bulletin 79* of the Hatch Experiment Station of Massachusetts.

Sunn-hemp, *Crotalaria juncea* and *C. tenuifolia*, as grown and used in India, is discussed in *Der Tropenpflanzer* for October.

An illustrated description of *Juncus textilis*, a new species from California, is distributed by Buchenau from the current volume of the *Abhandlungen* of the Bremen *Naturwissenschaftlicher Verein*.

A subject list of works on the textile industries and wearing apparel in the library of the British patent office, has recently been issued from that office.

No. 5 of the current volume of *Anales del Instituto Médico Nacional*, of the City of Mexico, contains the following articles of botanical interest; Villaseñor, Preliminares al estudio de las resinas; Armendaris, Algunas consideraciones sobre las propiedades fisilógicas de algunas plantas que contienen saponina; Noriega, Curso de historia de drogas, I.

The *Botanical Gazette* for October contains the following papers: — Land, A morphological study of Thuja; Copeland, The rise of the transpiration stream; Snow, Some notes on the ecology of the Delaware coast; Greenman, A new western Camassia.

The November number of the *Bulletin of the Southern California Academy of Sciences* contains the following botanical articles: — Davidson, *Sphærostigma erythra*; Parish, The southern California species of Calochortus, II; Greata, Tribal character in the separation of the style-branches in the Compositæ. The portion of Dr. Yates' Prehistoric California contained in this number is also largely devoted to fossil plants of that state.

The Fern Bulletin for October contains the following articles: — Davenport, Early fern study in America; Clute, A ten years' retrospect; Underwood, Some features of fern study; Druery, British fern culture; Smith, New Zealand ferns and fern study; Miyake, Notes on Japanese ferns; Gilbert, Historical sketch of the Linnean Fern Chapter; Eaton, A new Equisetum (*E. hiemale intermedium*), and a biographical sketch of Mr. Clute, with portrait.

Part I of Vol. XXVII of the *Journal of the Royal Horticultural Society*, dated September, 1902, contains a number of illustrated articles of more than passing botanical interest; among them, one by Dr. Cooke on Fungoid pests of the garden, one by Professor Carr on Plant communities, one on Weeds of the garden, by Mrs. Boyle, and one on Pelargonium disease, by Mr. Massee.

The New Phytologist, of October 30th, contains a discussion of Elementary university courses in botany, and a paper on Pryocysteæ, an obscure group of algæ, by Blackman, as well as a continuation of Blackman and Tansley's Revision of the classification of the green algæ.

Hefts 10 and 11 of Engler's *Das Pflanzenreich* consist, respectively, of the Tropæolaceæ, by Buchenau, and the Marantaceæ, by Schumann.

The Plant World for September contains the following principal articles: — Safford, Extracts from the note-book of a naturalist on the Island of Guam; Pollard, Frank Hall Knowlton; Cook, A deciduous tropical tree; Pammel, Our vanishing wild flowers; Hill, The etymology of Columbine; Rice, A carnivorous plant; Hopkins, A rare freak of the Trillium; and Kaufman, A carnivorous bog.

Rhodora for October contains the following articles: — Fernald, Two northeastern Veronicas; Graves, Valerianella in New England; Knowlton, Empetrum in Franklin County, Maine; Pease, *Hieracium prœaltum* at Andover, Mass., Webster, J. R., *Crepis virens* in Massachusetts; Shaw, New station for *Polypodium vulgare cambricum;* Bailey, Plant stations in Rhode Island; Scorgie, *Jasione montana* in Massachusetts; Webster, H., A new mushroom for the market; Deane, *Calluna vulgaris* in New Hampshire; Rich, Lists of New England plants, IX., Polygonaceæ.

The following articles of botanical interest appear in Vol. 7 of the second series of the *Transactions of the Royal Society of Canada*, recently issued: — Laflamme, Jacques-Philippe Cornuti — Note pour servir a l'histoire des sciences au Canada; Matthew, A backward step in palæo-botany; MacKay, Botanical bibliography of Canada, 1900.

A careful analytical account of the flora of the Galapagos Islands, by Dr. Robinson, with the collaboration of specialists, is published as No. 4 of the current volume of *Proceedings of the American Academy of Arts and Sciences*, and constitutes No. 24, n. s., of the *Contributions from the Gray Herbarium* of Harvard University.

No 22 of *North American Fauna* consists of a report on a biological investigation of the Hudson Bay region, by E. A. Preble, of some botanical and a great deal of zoological interest.

In current issues of the *Anales del Museo Nacional de Montevideo*, Professor Arechavaleta is describing and figuring a considerable number of new phanerogams, many of them belonging to genera which are also represented in North America.

As No. 6 of the papers issued by the Botanical Seminar of the University of Nebraska on the botanical survey of that state, a thesis

by G. G. Hedgcock has recently been published on The relation of the water content of the soil to certain plants, principally mesophytes.

A bulletin on dissemination, under the title "Plant travelers," by Professor Weed, is published as *Nature Study Leaflet No. 3* of the New Hampshire College Agricultural Experiment Station.

A paper by Matruchot and Molliard, on the Effects of frost on the structure of plant cells, is contained in the *Revue Générale de Botanique* for October 15th.

A lecture on Health and disease in plants, by F. S. Earle, is published in the *Journal of The New York Botanical Garden* for November.

Studies on cell division in cambium, by Schoute, have been issued from the *Verhandelingen der Koninkliijke Akademie van Wetenschappen*, of Amsterdam, under date of October, 1902.

A paper on the Cactaceæ of Costa Rica, by Dr. Weber, separately printed from No. 6 of the current volume of *Bulletin du Muséum d'histoire naturelle*, contains several new species of Cereus, Phyllocactus, Rhipsalis and Pereskia.

Echinacea purpurea and its varieties are considered in the *Revue Horticole* of November 1st.

An exhaustive local treatment of Salix, with reference to the forms, including hybrids, which occur about Regensburg, by Anton Mayer, is published as Heft VII of the *Berichte des naturwissenschaftlichen Vereines zu Regensburg*, for 1898–9.

An article on *Pinus lambertiana* is contained in *La Feuille des Jeunes Naturalistes*, of November 1st.

A paper on the Ferns of the Pacific Coasts, by Dr. Yates, is published in *Popular Science News* for November.

An illustrated monograph of the Ulothricaceæ and Chætophoraceæ of the United States, by T. E. Hazen, constitutes Vol. XI, No. 2, of the *Memoirs of the Torrey Botanical Club*.

No. 5 of the current volume of the *Bulletin du Jardin Impérial Botanique*, shows that at the beginning of the present year 35141 forms of plants were cultivated in the famous St. Petersburg Gardens, the herbarium of which is said to contain more than a million and a half of dried plants and the library to contain 29520 books comprising 14608 titles.

Some interesting notes on the Banksian Herbarium are contained in the *Journal of Botany* for November.

The Report of the committee on school gardens and children's herbariums, contained in No. 2 of the *Transactions of the Massachusetts Horticultural Society* for 1901, recently issued, is a very instructive document for those interested in nature work in the public schools.

Some of the results reached by an award for home and school grounds, Colorado Springs, Colo., are shown in *Park and Cemetery* for October.

A well illustrated and practical paper on Shade trees for city streets, by Murrill, is published as *Bulletin 205* of the Cornell University Agricultural Experiment Station.

A paper on the Colors and aromas of flowers, by Cadevall y Diars, constitutes Vol. IV, No. 27, of the *Memorias de la Real Academia de Ciencias y Artes de Barcelona.*

A paper in the *Bulletin of Miscellaneous Information*, No. 36, of the Botanical Department of Trinidad, states that Nepenthes is profitably grown in the West Indies among orchids as a means of catching cockroaches, which are said to be destructive to these plants.

An interesting Essay on the cultivation and curing of Vanilla, constitutes No. 35 of the *Bulletin of Miscellaneous Information*, issued by the Botanical Department of Trinidad.

The September number of the *Agricultural Bulletin of the Straits and Federated Malay States* is largely devoted to India rubber.

Economic fruits and seeds are taken up in Lieferung 10 of Wiesner's *Rohstoffe des Pflanzenreiches*, which is intended to be completed in one more Lieferung.

The cold storage of apples, with a consideration of the influence of cold storage on the decay of apples, and the chemical changes which occur during storage, by Morse, is published as *Bulletin 93* of the New Hampshire College Agricultural Experiment Station.

An illustrated paper, by Hartley, on injurious effects of premature pollination, with general notes on artificial pollination and the setting of fruit without pollination, has been published as *Bulletin No. 22* of the Bureau of Plant Industry, U. S. Department of Agriculture.

Recent economic papers published by the Department of Agriculture are: — Husmann, the manufacture and preservation of unfermented grape must, (*Bulletin No. 24*, Bureau of Plant Industry) and Bond and Keeney, Irrigation of rice in the United States (*Bulletin No. 113*, Office of Experiment Stations).

A paper by Emerson, giving a preliminary account of variation in bean hybrids, is separately printed from the *15th Annual Report* of the Agricultural Experiment Station of Nebraska.

A new forestry publication, *The Forestry Quarterly*, has been started from the New York State College of Forestry, at Cornell University. The first number appeared in October.

A practical analysis of farm forestry, by Chamberlain, is published, with numerous illustrations, in *Country Life in America* for November.

Papers on the Wilt disease of the Cowpea and its control, by Orton, and a Cowpea resistant to root knot, by Webber, are published as *Bulletin No. 17* of the Bureau of Plant Industry, U. S. Department of Agriculture.

Oudemans and Koning have distributed, in the form of separates from the *Archives Neerlandaises des Sciences Exactes et Naturelles*, a prodromus of a mycologic flora obtained by cultures on gelatine media of material derived from humus at Spanderswoud near Bussum. The paper is illustrated by 30 plates, mostly devoted to new and brightly colored species of molds.

A German variety of *Anthurus borealis* is described and figured by Hennings in the September–October *Beiblatt zur "Hedwigia."*

No. 105 of the *Proceedings of the Linnean Society of New South Wales* consists of several articles on Bacteria associated with the sugar cane, as well as other matter of botanical interest.

The Gardeners' Chronicle, of November 1st, contains description and figure of a convenient little vest-pocket micrometer for handy measurements, devised by Sir Joseph Hooker.

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

Chicago University, $1,500,000 from John D. Rockefeller; $526,000 from other sources.

Columbia University, $18,800 from various donors.

Fairmount (Kansas) College, $25,000 from Dr. D. K. Pearson.

Fargo College (North Dakota), $50,000 from Dr. D. K. Pearson.

Hamline (Minnesota) College, $250,000 from various donors.

Harvard University, $100,000, for a professorship of comparative anatomy, from James Stillman.

Illinois College, $50,000, from Dr. D. K. Pearson.

Johns Hopkins University, $25,000, from Dr. and Mrs. C. A. Hester.

Lafayette College, $2,500, by the will of Benjamin Barge.

Princeton University, $140,000, by the will of Mrs. Susan Dod Brown; $10,000, from Morris K. Jesup.

Radcliffe College of Harvard University, $116,000 from several donors.

Teachers College of Columbia University, a conditional gift of $500,000 from John D. Rockefeller; $274,509, from Mr. and Mrs. B. Everett Macy.

Tulane University, the residuary estate, estimated at about $1,000,000, of the late A. C. Hutchinson.

University of California, $111,000, for archæological purposes, from Mrs. Phoebe Hearst.

University of Georgia, a conditional gift of $50,000, from George Foster Peabody.

University of Pennsylvania, $100,000, from Dr. E. W. and C. H. Clark, for the chair in Assyriology.

University of Rochester, $10,000, from Mrs. Esther B. Steele.

Wesleyan University, $40,000, from Mr. Van Vleck, for an observatory.

Wooster (Ohio) University, $400,000, from various friends.

Yale University, $50,000, by the will of Mrs. Lena Courrier; $80,000, by the will of Benjamin Barge; $171,000, as residuary legatee of the estate of Edward Wills Southworth.

APPOINTMENTS.

E. B. Bailey, geologist of the Scottish Geological Survey.— E. D. Bell, professor of animal biology in the Utah Agricultural College.— Dr. Antonio Berlese, professor of zoölogy in the Agricultural School at Portici, Italy.—

Dr. Vincenz von Borbàs of Budapest, professor of systematic botany in the university at Klausenburg.— H. W. Britcher, instructor in zoölogy in the University of Maine.— Dr. Henry Coutiere, professor of zoölogy in the school of pharmacy at Paris.— Miss Clara Eaton Cummings, professor of botany in Wellesley College.— Dr. Eugen Dubois, professor of paleontology in the university at Amsterdam.— Dr. Durig, docent for physiology in the University of Vienna.— Dr. Martin H. Fischern, associate in physiology in the University of California.— Frances E. Foote, instructor in zoölogy in Wellesley College.— J. S. Gardiner, demonstrator in animal morphology in the University of Cambridge.— Dr. C. H. Gordon, instructor in geology and geography in the University of Nebraska.— R. P. Gregory, demonstrator in botany in the University of Cambridge.— Dr. Ludwig Heim, professor of bacteriology and hygiene in the university at Erlangen.— Dr. Addinel Hewson, assistant professor of anatomy in Jefferson Medical College.— Dr. Lorenz Hiltner, director of the newly established Agricultural-Botanical Institution at Munich.— Dr. P. P. C. Hoek, director of the Station for International Research at Copenhagen.— J. Allen Howe, curator and librarian of the Museum of Practical Geology.— Dr. J. A. Ippen, docent for mineralogy and petrography in the university at Graz.— Dr. O. Juel, professor of botany in the university at Upsala.— J. Graham Kerr, professor of natural history in the University of Glasgow.— Dr. Karl Ritter von Keissler, assistant in the Botanical section of the court museum at Vienna.— Dr. Jacques Loeb, professor of physiology in the University of California.— George Grant McCurdy, curator of the anthropological collections of Yale University.— Dr. Siegfried Mollier, second conservator of the anatomical institute at Munich.— Benjamin Moore, professor of biological chemistry in University College, Liverpool.— Dr. Willibad A. Nagel, professor extraordinary of physical physiology in the university at Berlin.— Dr. Joseph Nusbaum, professor of comparative anatomy in the University at Lemburg. — Dr. Oberhummer, professor of geography in the university at Vienna.— Dr. F. Wilhelm Pfaff, district geologist at Munich.— Dr. Charles Queva, professor of botany in the faculty of sciences at Dijon.— Dr. Karl Reichinger, assistant in the botanical section of the court museum at Vienna.— Dr. Otto M. Reis, district geologist at Munich.— Dr. Charles D. Rogers, assistant in physiology in the University of California.— Dr. Wladislaw Rothert, professor of botany in the university at Odessa.— Dr. Johannes Rückert, first conservator of the anatomical institute at Munich.— A. Schwagger, district geologist at Munich.— Dr. Hans Strahl, professor of anatomy in the university at Tübingen.— Dr. Emil Lietze, director of the royal geological survey in Vienna.— Dr. J. B. de Toni, professor of botany in the university at Modena.— Dr. F. Vejdovsky, transferred from the chair of embryology and comparative anatomy in the university at Prag, to that of zoölogy.— Dr. I. G. de Vries, director of the Zoological Station at the Helder.— Dr. Friedrich Vierhapper, assistant in the Botanical Garden and Museum at Vienna.— C. F. Myers Ward, lecturer in physiology in Charing Cross Hospital Medi-

cal School.— Alice V. Wilcox, instructor in zoölogy in Wellesley College.— Dr. Ernst Wilczek, professor of botany in the university at Lausanne.— Dr. F. A. Wilder, state geologist and professor of geology in the University of North Dakota.

RETIREMENTS.

Dr. Anton Fričˇ from the chair of zoölogy in the university at Prag.— Dr. Guido Stache from the directorship of the Austrian Geological Survey.

DEATHS.

Homer Franklin Bassett, student of Hymenoptera at Waterbury, Conn., June 28, aged 76.— Dr. Andreas Nikol Betekow, formerly professor of botany in the Universities at Charkow and St. Petersburg, July 14.— Mr. R. A. Blair, geologist, at Sedalia, Missouri.— Ladislava Celakowskèho, professor of botany in the Bohemian University at Prag, aged 69.— Vincent Leche Chesnevieux, geologist and traveler, aged 86.— Thomas Comber, botanist, in Blackpool, England, January 24, 1902.— Dr. J. G. Cooper, zoölogist, in Haywards, California, July 19, aged 72.— Augustin Alexis Damour, mineralogist, in Paris, September 21, aged 94.— M. Dehérain, professor of plant physiology in the Paris Museum of Natural History.— Louise Brisbin Dunn, tutor in botany in Barnard College, December 18.— Dr. Rudolf Finkener, professor of mineral analysis in the mining academy in Berlin, September 14, aged 68.— Dr. A. Frenzel, mineralogist and ornithologist, in Freiburg in Sachsen, in August.— Mr. William Gunn, district geologist of the British Geological Survey, October 23, aged 65.— Dr. Theodor von Heldrich, professor of botany and director of the botanical gardens in Athens, September 7.— Dr. Johann Janko, director of the ethnographical section of the Hungarian Museum at Budapest, aged 34.— Ludwig Kumlein, naturalist of the Howgate expedition, in Milton, Wisconsin, in December.— Dr. Carl von Kupffer, professor of anatomy in the university at Munich, December 16, aged 73.—Dr. Eduard Lehmann, student of the flora of Livonia, May 5, aged 61.— Major James C. Merrill, M. D., ornithologist, aged 49.— Dr. Ernst Meynert, professor extraordinary of anatomy in the university at Halle, aged 39.— Mark Micheli, botanist, in Geneva, July 10.— Dr. Millardet, professor of botany at Bordeaux.— Dr. Ludwig Molendo, bryologist, in Munich, July 25, aged 68.— T. A. Clemens Müller, coleopterist, in Dresden, August 16, aged 74.— Dr. William Miller Ord, formerly tutor for physiology in St. Thomas Hospital, London, aged 68.— P. Anselm Pfeiffer, naturalist, in Kremmünster, July 7, aged 54.— Dr. Samuel Leopold Schenk, formerly professor of embryology in the university at Vienna, August 18, aged 62.— Dr. A. R. C. Selwyn, formerly director of

the Canadian Geological Survey, at Vancouver, October 19, aged 78.— Franz Sikora, a natural history explorer of Madagascar and Réunion.— Dr. Franz Tappeiner, anthropologist, in Meran, Tyrol, August 19, aged 82.— Dr. Adolfo Targione-Tozetti, formerly professor of comparative anatomy at Florence, September 18, aged 79.— Dr. Rudolf Virchow, since 1856 professor of pathology in the university at Berlin, September 5, aged 80.— J. B. Williamson, student of Lepidoptera, in Slough, England, June 21, aged 74.— Dr. Oliver Willis, botanist at White Plains, N. J., April 27, aged 88. — Rev. Dr. Wiltshire, geologist, in London, October 25.

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